U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-271 985

Developing Economic Impact Projection Models for the Fort Union Coal Region

North Dakota State Univ, Fargo Dept of Agricultural Economics

Prepared for

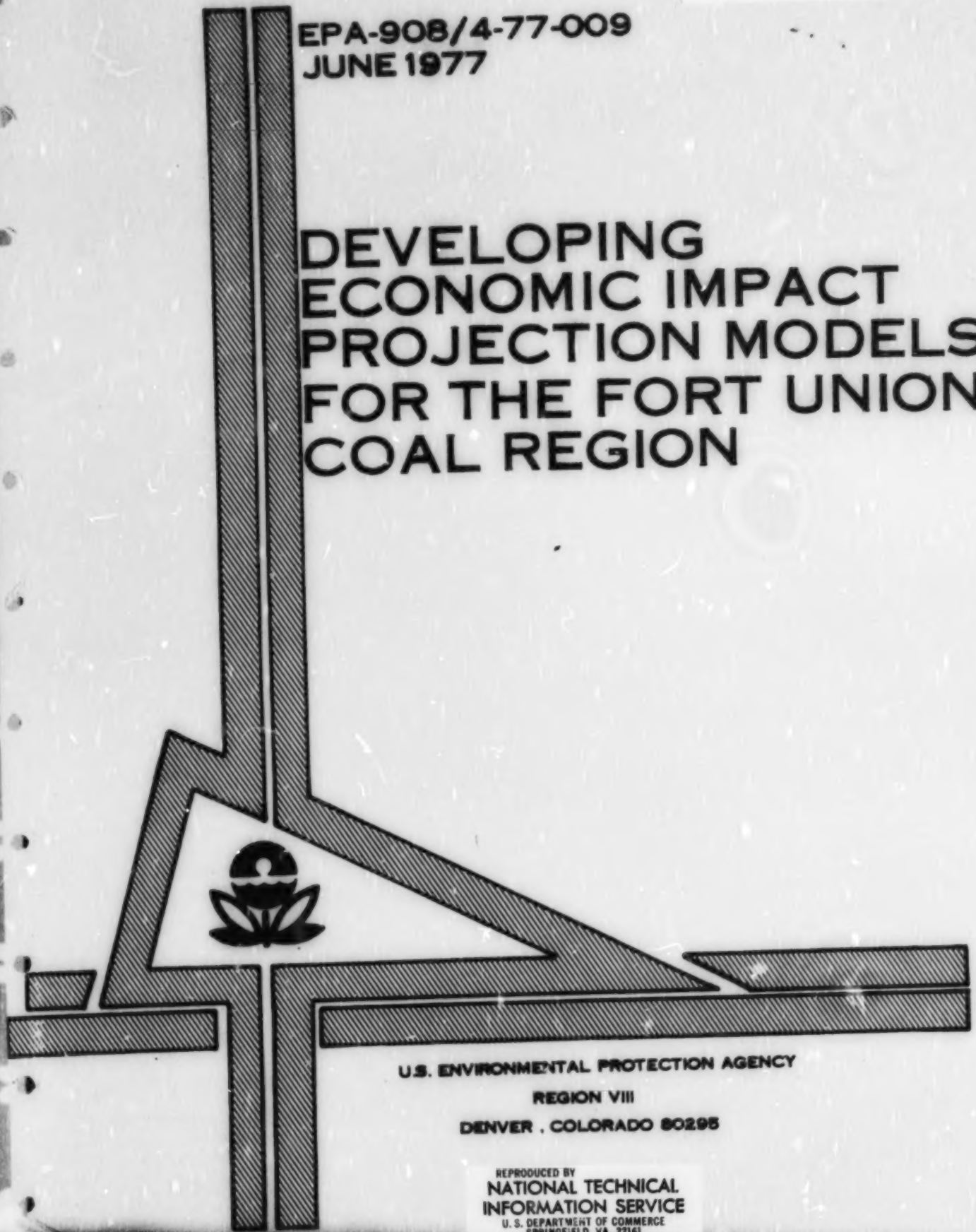
Environmental Protection Agency, Denver, Colo Region VIII

Jun 77

PB 271 985

EPA-908/4-77-009
JUNE 1977

DEVELOPING ECONOMIC IMPACT PROJECTION MODELS FOR THE FORT UNION COAL REGION



U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VIII
DENVER, COLORADO 80295

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-908/4-77-009	2.
3. RECIPIENT'S ACCESSION NO. PB-271 985	
4. TITLE AND SUBTITLE: Developing Economic Impact Projection Models for the Fort Union Coal Region	5. REPORT DATE: June 1977
	6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S): Thor A. Hertsgaard, Randal C. Coon, F. Larry Leistritz, Norman L. Dalsted	8. PERFORMING ORGANIZATION REPORT NO.: No. 77030
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Department of Agricultural Economics, North Dakota State University, Fargo, North Dakota 58102	10. PROGRAM ELEMENT NO.
	11. CONTRACT/GRANT NO.: 68-01-3507
12. SPONSORING AGENCY NAME AND ADDRESS: U.S. Environmental Protection Agency, 1860 Lincoln Street, Denver, Colorado 80295	13. TYPE OF REPORT AND PERIOD COVERED: Final
	14. SPONSORING AGENCY CODE: EPA 908/04

15. SUPPLEMENTARY NOTES

16. ABSTRACT This report is the initial phase of a study to develop, adapt, and integrate models for evaluating the economic effects of expanded coal mining and conversion in the Northern Great Plains (Fort Union) Region. Work under Phase I was designed to determine the usefulness for describing interindustry relationships in western North Dakota, southeastern Montana, and northeastern Wyoming of input-output coefficients previously developed for North Dakota. The 17 sector model (which includes coefficients collected in Phase I for the coal mining, coal fired thermal electric generating, petroleum and natural gas extraction, and petroleum refining sectors) provides personal income estimates that coincide more closely with Department of Commerce estimates than do those obtained with the earlier 13 sector model. It appears that the input-output model can be used for estimating the potential effects of coal resource development in North Dakota.

The model does not perform as well for northeastern Wyoming and southeastern Montana as in North Dakota. The fact the input-output model invariably underestimates personal income in Montana and Wyoming implies that the model leaves something to be described for describing the level of economic activity in those states. However, the model does provide estimates that appear to "track" quite consistently with Department of Commerce data, but with a predictable downward bias. The rather constant downward bias in the historical comparison may allow the model to be used for impact analysis of coal resource development in the two states.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Economic Models; Economic Sectors; Population; Employment; Personal Income; Gross Business Volume; Final Demand Vectors; Interindustry Relationships; Input-Output Coefficients; Coal Mining; Coal Conversions		

18. DISTRIBUTION STATEMENT: Unlimited Distribution	19. SECURITY CLASS (This Report): Unclassified	21. NO. OF PAGES: 58
	20. SECURITY CLASS (This page)	22. PRICE: PC A04/MF A01

EPA Form 2220-1 (9-73)

DEVELOPING ECONOMIC IMPACT PROJECTION MODELS FOR THE FORT UNION COAL REGION

Report No. 77030

By
Thor A. Hertsgaard
Randal C. Coon
F. Larry Leistritz
Norman L. Dalsted

Department of Agricultural Economics
North Dakota State University
June 30, 1977

Project 68-01-3507

Project Officer
Mr. George Collins
Region VIII
Environmental Protection Agency
Denver, Colorado 80203

DISCLAIMER

This report has been reviewed by the Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22151.

Table of Contents

	Page
Introduction	1
Procedures	1
The Model	3
Evaluation of the Model	5
State of North Dakota	5
Regions in North Dakota	10
Montana	21
Wyoming	21
Conclusions	28
Recommendations for Further Work	34
Appendix A	35
Appendix B	46
List of Tables	51
List of Figures	51

INTRODUCTION

This report describes the results of work under Phase I of a study to develop, adapt, and integrate models for evaluating the economic effects of expanded coal mining and conversion in the Northern Great Plains (Fort Union) Region. Work under Phase I was designed to determine the usefulness for describing interindustry relationships in western North Dakota, southeastern Montana, and northeastern Wyoming of input-output coefficients previously developed for North Dakota.

Phase II, if required, would involve modification of the North Dakota input-output tables to obtain coefficients which more accurately depict interindustry relationships in the coal impact areas of eastern Montana and northeastern Wyoming. Such modification likely would involve collection of expenditures data for those sectors in Montana and Wyoming that are believed to be significantly different from their counterparts in North Dakota. Technical input-output coefficients would be computed for those sectors and those coefficients would be substituted in the computation of a revised interdependence coefficients matrix.

Phase III will involve the use of the input-output coefficients evaluated in Phase II (and/or Phase I) to assess the potential effects of coal resource development in the Fort Union Region.

PROCEDURES

The general procedures involved application of the interdependence coefficients to the final demand vectors for each state and the relevant regions within the respective states. Final demand vectors are defined as production for final demand by the several economic sectors in the regions that result in a flow of funds into the region from the "rest-of-the-world."

These receipts consist of sales of livestock and crops, products of mines, manufactured products, as well as federal government outlays and tourist expenditures in the region.

Multiplication of the interdependence coefficients and the final demand vector for the respective state or region yielded estimates of the gross business volumes for each of the economic sectors in the state or region. Data were assembled from secondary sources (Appendix A) to provide estimates of sales for final demand by the respective sectors in each of the regions and states for the years 1958-1975. Multiplications of the matrix of interdependence coefficients by the vector of sales for final demand yielded estimates of total personal income (as well as estimates of gross business volumes of each of the other sectors) for each of the years for the respective states and regions. The gross business volume of the household sector, except for minor definitional differences, is equivalent to personal income. These estimates were compared to those published by the Bureau of Economic Analysis, U.S. Department of Commerce, at both the state and regional level.

Because of the fact that U.S. Department of Commerce estimates of personal income for substate geographic areas also may be subject to some degree of error, another independent method was used to disaggregate personal income in each state to the regional level. This method is described in Appendix B. The method involved disaggregation of personal income from the state to the county level in each state for each year and reaggregation to the regions of interest. These estimates were then compared to those derived by input-output techniques.

(The reader should note that comparison of regional personal income estimates based in input-output analysis with those based on disaggregation procedures involved comparisons for 18 years whereas only 12 years of estimates were available from the U.S. Department of Commerce.)

THE MODEL

Stadig[1] was the first to collect primary data for an input-output model in North Dakota, but initial efforts to gather large quantities of data began in 1965. Sand[2] and Bartch[3] collected data in southwestern North Dakota from a sample of firms, households, and governmental units that were used to describe the structure of the North Dakota economy and to project the economic impacts of selected types of development in the state. They derived technical input-output coefficients and interdependence coefficients for a 30-sector model of the North Dakota economy.

Lutovsky[4] and Senechal[5] subsequently explored procedures for testing the validity of the coefficients derived by Sand and Bartch. They concluded that the coefficients developed for southwestern North Dakota also were valid for other parts of the state. However, they recommended that some of the 30 sectors defined by Sand and Bartch be aggregated into fewer sectors. Accordingly, data collected by Sand and Bartch subsequently have been aggregated into a set of 13 sectors. Most of the sectors involved were retail

---

[1]Stadig, L. L., Economic Interrelationships Among Sectors of a Local Economy with Special Emphasis on Agriculture: Lisbon, North Dakota, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1964.

[2]Sand, L. D., Analysis of Effects of Income Changes in Intersectoral and Intercommunity Economic Structure, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1966.

[3]Bartch, B. L., Analysis of Intersectoral and Intercommunity Structure in Southwestern North Dakota, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1968.

[4]Lutovksy, R. F., Interindustry Analysis of the North Dakota Economy, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1968.

[5]Senechal, D. M., Analysis of Validity of North Dakota Input-Output Models, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1971.

trade sectors, which were aggregated into a single retail trade sector (Sector 8).

The principal intended use for which input-output coefficients initially were assembled in North Dakota was for projecting the economic impacts of irrigation development in the state. However, since the data were collected, a wide variety of applications has been made. The major use of the model recently has been for estimating the economic and social impacts of coal resource development.

The original model developed by Sand and Bartch had only one sector to describe the various mining activities within the state. This sector reflected the characteristics of firms in southwestern North Dakota that were engaged in sand and gravel mining but did not include such activities as coal and petroleum mining. The omission of coal and petroleum mining was not a serious deficiency in the model as long as the major component of the state's economic base was agriculture and as long as there were no important interdependencies of other economic sectors with coal and petroleum mining. However, the increasing importance of mining as a component of the state's economic base and the prospects for accelerated development of coal conversion facilities in the state resulted in a need for more detailed input-output data for the energy sectors.

Part of the efforts under Phase I of this project involved collection of expenditures data in North Dakota from firms in four additional sectors related to energy production. These sectors were coal mining, thermal-electric power generation, petroleum and natural gas extraction, and petroleum refining. Technical input-output data were computed for these sectors and the results were augmented to those previously available for other sectors.

The augmented matrix of input-output coefficients was the basis for computation of a set in interdependence coefficients for the 17-sector model of the North Dakota economy.

The 17 sectors and the Standard Industrial Classification (SIC) Code numbers corresponding to each are presented in Table 1. The interdependence coefficients that were computed for the 17-sector model are presented in Table 2.

EVALUATION OF THE MODEL

The input-output interdependence coefficients developed for North Dakota were evaluated at the state level for North Dakota, Montana, and Wyoming and also at the regional level for the coal producing regions of those states. In each case, final demand vectors were computed for the state or region, and then were multiplied by the interdependence coefficients to obtain the level of personal income generated by that level of export for final demand. These estimates of personal income were compared with those published by the U.S. Department of Commerce.

State level estimates of sales for final demand by the "basic" sectors were based on secondary data sources. Some difficulty was experienced in estimating out-of-state sales for some components of final demand and this tended to be an even greater problem at the regional level. Where good data existed at the county level, it was the source for aggregations of county data into regional totals.

State of North Dakota

Final demand vectors for the state of North Dakota for the years 1958-1975 are presented in Table 3. Sales of livestock and crops are in Columns A and B. Exports of coal and petroleum are in Columns H and J.

TABLE 1. ECONOMIC SECTORS OF INPUT-OUTPUT MODEL AND SIC CODE NUMBERS OF EACH

Economic Sector	SIC Code[a]
1. Ag., Livestock	Group 013, - Livestock
2. Ag., Crops	All of Major Group 01 - Agricultural Production, Except Group 013 - Livestock
3. Sand and Gravel Mining	Major Group 14 - Mining and Quarrying of Nonmetallic Metals, Except Fuels
4. Contract Construction	Division C - Contract Construction (Major Groups 15, 16, and 17)
5. Transportation	All Division E - Transportation, Communications, Electric, Gas, and Sanitary Services, Except Major Groups 48 and 49.
6. Communication and Utilities	Major Group 48 - Communication and Major Group 49 - Electric, Gas, and Sanitary Services (Except Industry No. 4911)
7. Wholesale Trade and Ag. Processing	Major Group 50 - Wholesale Trade and Major Group 20 - Food and Kindred Products Manufacturing
8. Retail Trade	All of Division F - Wholesale and Retail Trade, Except Major Group 50 - Wholesale Trade
9. Finance, Insurance, and Real Estate	Division G - Finance, Insurance, and Real Estate
10. Business and Personal Services	All Division H - Services, Except Major Groups 80, 81, 82, 86, and 89
11. Professional and Social Services	Major Group 80 - Medical and Other Health Services, Major Group 81 - Legal Services, Major Group 82 - Educational Services, Major Group 86 - Nonprofit Membership Organizations, Major Group 89 - Miscellaneous Services
12. Households	Not Applicable
13. Government	Division I - Government
14. Coal Mining	Major Group 12 - Bituminous Coal and Lignite Mining
15. Thermal-Electric Power Generation	Industry Number 4911 - Electric Companies and Systems
16. Petroleum and Natural Gas Extraction	Major Group 13 - Crude Petroleum and Natural Gas
17. Petroleum Refining	Major Group 29 - Petroleum Refining and Related Industries

[a]Executive Office of the President/Bureau of the Budget, Standard Industrial Classification Manual, 1967, U.S. Government Printing Office, Washington, D.C., 1967.

TABLE 2. INTERDEPENDENCE COEFFICIENTS FOR BASIC ECONOMIC SECTORS, NORTH DAKOTA

Sector	(1) Agriculture, Livestock	(2) Agriculture, Crops	(4) Contract Construction	(7) Wholesale Trade & Ag Processing	(8) Retail Trade	(10) Business & Personal Service	(12) Households	(14) Coal Mining	(15) Electric Generating	(16) Petroleum/ Natural Gas Extraction	(17) Petroleum Refining
1. Ag, Livestock	1.21	0.08	0.03	0.19	0.09	0.04	0.07	0.04	0.03	0.02	0.01
2. Ag, Crops	0.39	1.09	0.01	0.65	0.03	0.02	0.03	0.03	0.03	0.01	0.01
3. Sand & Gravel Mining	0.01	0.01	0.03	0.01	a	a	0.01	a	a	a	a
4. Contract Construction	0.07	0.08	1.05	0.06	0.03	0.05	0.09	0.05	0.03	0.11	0.09
5. Transportation	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	a	0.02	0.02
6. Comm. & Utilities	0.09	0.08	0.06	0.08	0.05	0.11	0.11	0.07	0.04	0.05	0.04
7. Wholesale Trade & Ag Proc.	0.57	0.16	0.02	1.74	0.05	0.02	0.04	0.06	0.08	0.01	0.01
8. Retail Trade	0.71	0.81	0.41	0.61	1.27	0.45	0.74	0.40	0.23	0.18	0.17
9. Fin., Ins., & Real Estate	0.15	0.17	0.08	0.13	0.06	0.11	0.17	0.08	0.10	0.04	0.04
10. Bus. & Pers. Service	0.06	0.07	0.03	0.05	0.02	1.05	0.06	0.03	0.02	0.01	0.01
11. Prof. & Soc. Service	0.07	0.06	0.04	0.05	0.03	0.05	0.10	0.05	0.03	0.02	0.02
12. Households	1.05	0.96	0.61	0.79	0.40	0.72	1.55	0.67	0.40	0.32	0.30
13. Government	0.10	0.10	0.05	0.08	0.04	0.08	0.11	0.05	0.04	0.03	0.03
14. Coal Mining	a	a	a	a	a	a	a	1.00	0.16	a	a
15. Elec. Gen.	a	a	a	a	a	a	a	a	1.00	a	a
16. Petro./N. Gas Extraction	a	a	a	a	a	a	a	0.01	0.01	1.10	0.82
17. Petro. Refining	a	a	a	a	a	a	a	0.02	0.01	a	1.00
Gross Receipts Multiplier	4.49	3.69	2.44	4.45	2.09	2.71	3.08	2.57	2.21	1.92	2.57

[a]Less than 0.005.

TABLE 3. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1975 (MILLION DOLLARS)

Year	(A) Agriculture, Livestock	(B) Agriculture, Crops	(C) Contract Construction	(D) Wholesale Trade & Ag Processing	(E) Retail Trade	(F) Business & Personal Service	(G) Households	(H) Coal Mining	(I) Electric Generating	(J) Petroleum/ Natural Gas Extraction	(K) Petroleum Refining	Total
1958	220.3	440.3	18.3	62.5	16.5	5.5	187.0	1.1	--	5.4	13.1	970.0
1959	217.3	394.9	27.2	57.0	18.0	6.0	186.5	1.0	--	10.9	12.9	931.7
1960	175.4	390.9	32.7	66.1	14.9	5.0	187.9	1.0	--	14.5	12.5	900.9
1961	213.9	341.7	24.0	67.5	17.2	5.8	237.2	1.3	--	21.0	12.6	942.2
1962	199.3	476.8	16.5	62.6	18.7	6.3	344.2	1.5	--	22.8	12.5	1,161.2
1963	207.7	543.1	17.1	73.0	21.7	7.2	334.5	1.3	--	23.3	12.5	1,241.4
1964	213.3	451.2	30.2	78.4	26.2	8.7	485.2	1.5	--	25.9	12.7	1,333.3
1965	247.5	554.5	31.0	78.4	33.0	11.0	361.4	1.5	--	28.0	13.4	1,359.7
1966	271.5	609.4	23.3	84.2	45.0	15.0	428.6	1.3	4.4	29.7	14.0	1,526.4
1967	280.9	568.4	24.4	91.7	54.7	18.2	380.8	2.1	8.4	28.0	14.6	1,472.2
1968	264.2	570.5	27.0	101.5	69.7	23.2	447.9	2.4	12.3	34.3	14.7	1,567.7
1969	265.0	641.8	35.2	162.0	75.8	25.3	501.5	2.4	11.7	26.2	14.9	1,761.8
1970	272.5	671.0	182.1	148.1	85.7	28.5	567.7	3.2	13.8	30.3	15.2	2,018.1
1971	304.7	673.7	60.7	162.0	93.8	31.3	605.1	3.5	17.5	32.9	16.0	1,969.9
1972	367.4	975.0	72.9	170.0	86.3	28.8	649.0	3.3	21.4	34.6	17.0	2,425.7
1973	475.9	1,795.7	61.6	243.0	94.5	31.5	726.7	4.1	19.3	38.4	19.2	3,509.9
1974	448.5	2,072.1	72.3	304.8	92.6	30.9	806.0	4.9	22.4	76.1	22.8	3,953.4
1975	452.8	1,555.8	82.9	306.6	112.5	37.5	1,046.9	7.1	21.6	93.1	27.2	3,744.0

Manufactured exports are in Columns D, I, and K. Estimated outlays for tourism are allocated in Columns E and F, while federal government outlays for construction is Column C and federal payrolls is Column G.

The estimates of personal income obtained by input-output techniques are presented in the first column of Table 4. For each year, the result is the sum of the products of the sales by the column sector (Table 3) and the coefficient in Row 12 of the interdependence coefficients matrix (Table 2) for that sector. For example, the $1,022 million of estimated personal income in 1958 (Table 4) is equal to ($220.3 million x 1.05) + ($440.3 million x .96) + ($18.3 million x .61) + ($62.5 million x .79) + ($16.5 million x .40) + ($5.5 million x .72) + ($187.0 million x 1.55) + ($1.1 million x .67) + ($5.4 million x .32) + ($13.1 million x .30) = $231.3 million + $422.7 million + $11.2 million + $49.4 million + $6.6 million + $4.0 million + $289.9 million + $0.7 million + $1.7 million + $4.0 million. (The data shown in the above example are rounded numbers which are slightly different from the unrounded ones from the computer calculations.)

The results of these calculations for each year were compared with estimates of personal income in North Dakota that are assembled by the U.S. Department of Commerce, which appear in the second column of Table 4. The last column of the table indicates the difference in the first two columns, expressed as a percentage of the Department of Commerce estimate. This difference is less than 5 percent for 10 of the 18 years and only 6 years have differences of more than 6 percent. Of these 6 years, one was 1964 (when the Minuteman construction was occurring) and another was 1970 (when the ABM construction was in progress). Input-output analysis overestimated personal income in those years because reporting of government outlays

TABLE 4. PERSONAL INCOME, NORTH DAKOTA, 1958-1975

Year	Estimated by Input-Output Techniques ($000)	Reported by U.S. Department of Commerce ($000)[a]	Percentage Difference
1958	$1,022,420	$1,027,000	-0.5
1959	978,397	953,000	2.7
1960	942,474	1,081,000	-12.8
1961	1,011,456	964,000	4.9
1962	1,285,782	1,361,000	-5.5
1963	1,353,838	1,283,000	5.5
1964	1,521,163	1,272,000	19.6
1965	1,470,114	1,498,000	-1.9
1966	1,662,434	1,556,000	6.8
1967	1,572,975	1,595,000	-1.4
1968	1,684,427	1,644,000	2.5
1969	1,890,981	1,850,000	2.2
1970	2,117,311	1,913,000	10.7
1971	2,156,709	2,173,000	-0.7
1972	2,592,109	2,545,000	1.9
1973	3,674,768	3,663,000	0.3
1974	4,104,582	3,629,000	13.1
1975	4,013,695	3,652,000	9.9
Average Difference[b]			5.72

[a]As reported by the Bureau of Economic Analysis, U.S. Department of Commerce, in Survey of Current Business, August, 1976.
[b]Without respect to sign.

implied that all the expenditures occurred in those years, whereas they actually were distributed over more than one year.

Figure 1 indicates the results of the analysis in graphic form. The solid line indicates North Dakota personal income reported by the Department of Commerce for the years 1958-1975. The dotted line represents estimates for those years obtained from the input-output model.

Regions in North Dakota

The regions in North Dakota for which exports of coal, electricity, or crude or refined petroleum constitute a part of the economic base are Regions 1, 2, 7, and 8 (Figure 2). Final demand vectors for those regions for the years 1958-1975 are presented in Table 5.

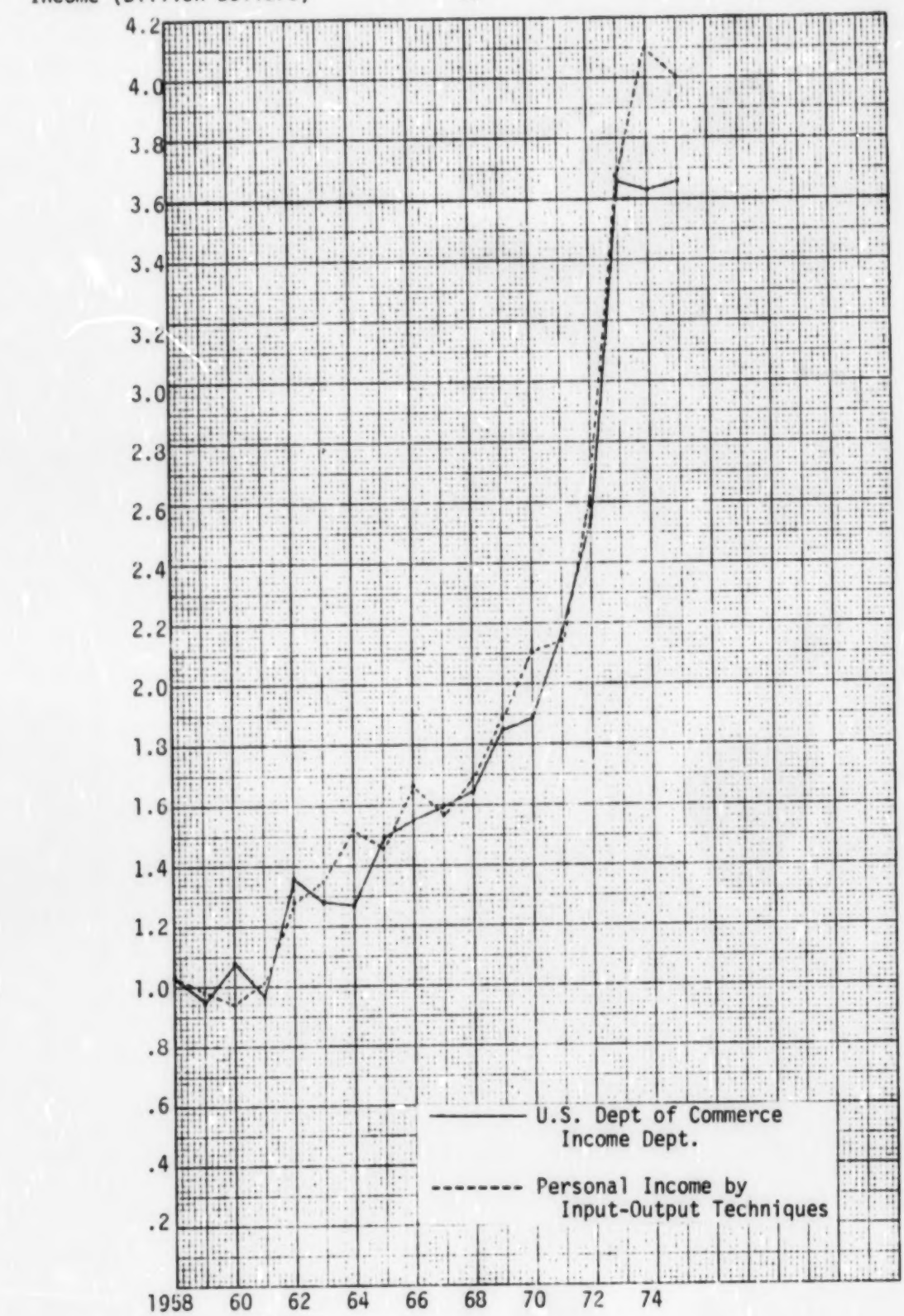


Figure 1. Personal Income in North Dakota, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975.

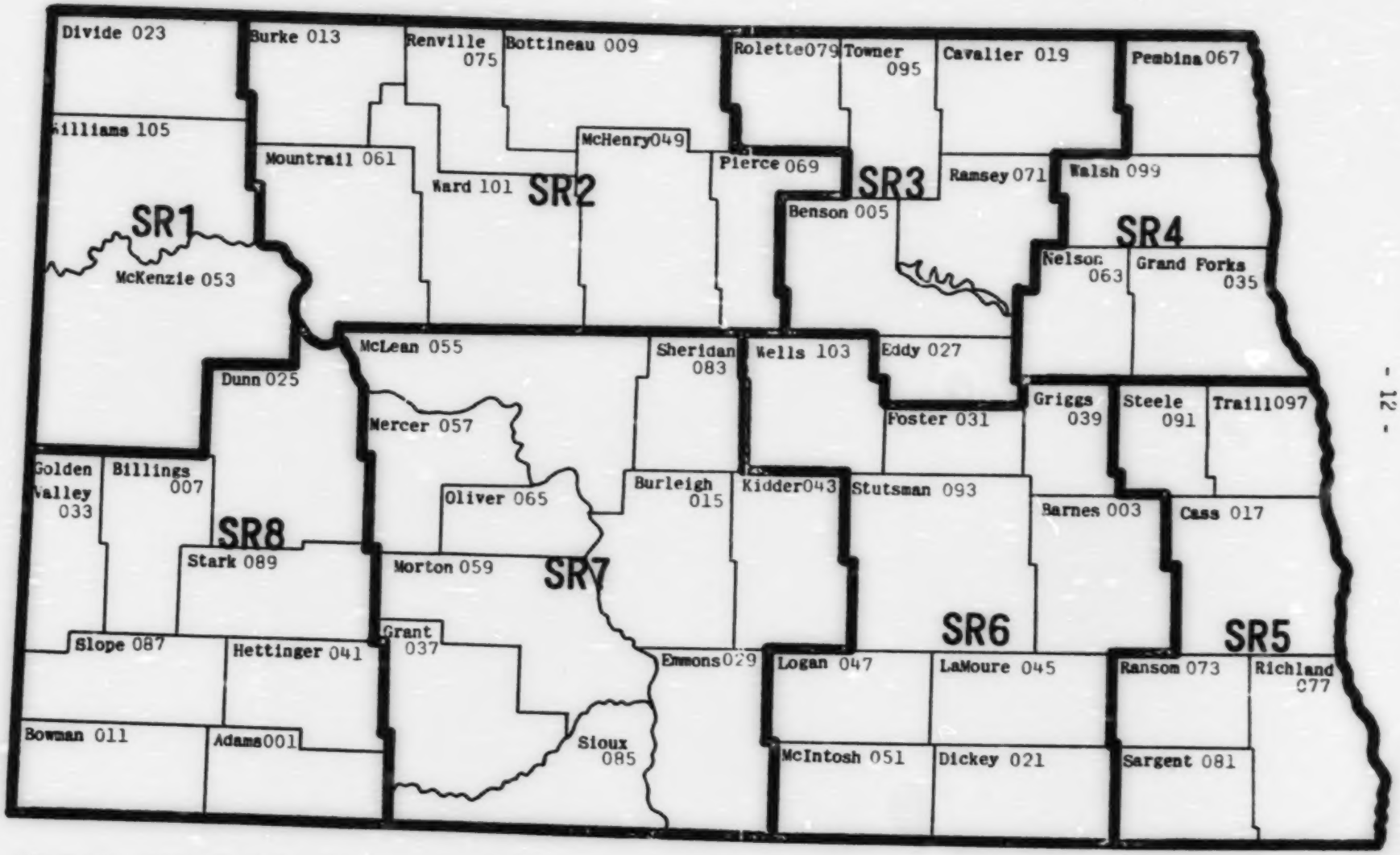


Figure 2. State Planning Regions in North Dakota.

TABLE 5. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA REGIONS, 1958-1975 (MILLION DOLLARS)

Year	(A) Agriculture, Livestock	(B) Agriculture, Crops	(C) Contract Construction	(D) Wholesale Trade & Ag Processing	(E) Retail Trade	(F) Business & Personal Service	(G) Households	(H) Coal Mining	(I) Electric Generating	(J) Petroleum/ Natural Gas Extraction	(K) Petroleum Refining	(L) Total
						Region 1						
1958	10.3	16.2	.8	2.7	.9	.3	5.8	.1	--	17.6	4.8	59.5
1959	9.8	14.4	1.1	2.3	1.0	.3	6.4	.1	--	20.7	4.7	60.8
1960	8.0	19.2	1.4	2.6	.8	.3	7.3	.1	--	25.5	4.6	69.8
1961	10.0	10.6	1.1	2.5	1.0	.3	7.6	.2	--	26.5	4.6	64.4
1962	9.2	28.4	.7	2.2	1.0	.3	9.5	.2	--	30.2	4.6	86.3
1963	10.1	36.2	.8	2.4	1.2	.4	9.8	.1	--	32.7	4.5	98.2
1964	10.9	24.2	1.3	2.6	1.5	.5	12.8	.1	--	36.3	4.4	94.6
1965	13.1	26.5	1.4	2.6	1.8	.6	11.0	--	--	37.6	4.6	99.2
1966	14.3	32.9	1.0	2.8	2.5	.8	12.5	--	--	38.8	4.6	110.2
1967	14.8	28.2	1.1	3.1	3.0	1.0	12.0	--	--	33.4	4.6	101.2
1968	13.9	26.4	1.2	3.3	3.8	1.3	13.7	--	--	33.4	4.6	101.6
1969	13.8	40.0	1.5	5.4	4.2	1.4	21.0	--	--	28.2	4.7	120.2
1970	15.0	38.3	.7	4.9	4.7	1.6	18.9	--	--	28.9	5.1	118.1
1971	17.9	34.1	.7	5.4	5.2	1.7	23.0	--	--	31.3	6.1	125.4
1972	21.5	59.6	2.5	5.6	4.7	1.6	22.8	--	--	31.3	6.4	156.0
1973	26.8	115.2	.3	8.0	5.2	1.7	25.6	--	--	33.2	7.3	223.3
1974	23.4	128.0	1.1	10.1	5.1	1.7	27.3	--	--	72.0	8.6	277.3
1975	22.7	85.5	.9	10.2	6.2	2.1	31.0	--	--	86.4	9.6	254.6
						Region 2						
1958	24.2	46.9	2.2	7.8	2.5	.9	31.3	--	--	7.3	--	123.1
1959	22.9	50.1	3.3	7.4	2.8	.9	29.1	--	--	12.5	--	129.0
1960	18.8	53.0	3.9	8.8	2.3	.8	33.0	--	--	16.8	--	137.4
1961	23.3	23.2	2.9	9.3	2.7	.9	39.1	--	--	20.9	--	122.3
1962	21.5	85.4	2.0	8.9	2.9	1.0	78.9	--	--	21.7	--	222.3
1963	22.5	89.0	2.1	10.6	3.4	1.1	69.7	--	--	21.6	--	220.0
1964	23.3	74.7	3.6	11.3	4.0	1.4	124.1	--	--	24.0	--	266.4
1965	27.2	78.2	3.7	11.3	5.1	1.7	71.0	--	--	25.4	--	223.6
1966	28.4	95.8	2.8	12.1	6.9	2.3	91.8	--	--	23.6	--	263.7
1967	29.9	65.7	2.9	13.5	8.4	2.8	68.8	--	--	21.5	--	213.5
1968	26.2	72.5	3.2	14.7	10.7	3.6	89.0	--	--	21.5	--	241.4
1969	26.0	95.8	2.1	23.3	11.7	3.9	102.6	--	--	20.0	--	285.4
1970	28.1	94.2	2.9	21.3	13.2	4.4	129.5	--	--	21.5	--	315.1
1971	35.5	91.7	5.0	23.3	14.4	4.8	131.4	--	--	24.4	--	330.5
1972	39.7	133.6	4.2	24.5	13.3	4.4	120.4	--	--	25.8	--	365.9
1973	49.2	311.3	7.0	34.9	14.6	4.9	146.7	--	--	25.6	--	594.2
1974	45.2	300.8	5.7	43.8	14.3	4.8	178.0	--	--	47.9	--	640.5
1975	44.8	205.0	5.4	44.1	17.3	5.8	297.3	--	--	57.8	--	677.5

- continued -

TABLE 5. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA REGIONS, 1958-1975 (MILLION DOLLARS) (CONTINUED)

Year	(A) Agriculture, Livestock	(B) Agriculture, Crops	(C) Contract Construction	(D) Wholesale Trade & Ag Processing	(E) Retail Trade	(F) Business & Personal Service	(G) Households	(H) Coal Mining	(I) Electric Generating	(J) Petroleum/ Natural Gas Extraction	(K) Petroleum Refining	(L) Total
						Region 7						
1958	54.3	50.2	3.4	11.7	2.8	.9	24.3	.6	--	--	38.8	187.0
1959	53.4	31.0	5.1	10.3	3.0	1.0	27.0	.5	--	--	38.2	169.5
1960	41.6	40.7	6.0	11.6	2.5	.8	30.7	.6	--	--	37.1	171.6
1961	52.6	14.1	4.5	11.6	2.9	1.0	32.1	.8	--	--	37.4	157.0
1962	47.3	63.7	3.0	10.5	3.2	1.1	40.3	.9	--	--	37.2	207.2
1963	50.7	54.9	3.2	11.7	3.7	1.2	41.3	.8	--	--	37.1	204.6
1964	53.2	52.5	5.6	12.6	4.4	1.5	54.5	1.1	--	--	37.9	223.3
1965	62.2	60.7	5.7	12.6	5.5	1.8	46.4	1.3	--	--	40.0	236.2
1966	71.6	66.5	4.3	13.5	7.6	2.5	53.1	1.2	4.4	--	42.0	266.7
1967	73.5	54.6	4.5	15.0	9.2	3.1	50.7	1.8	8.4	--	43.9	264.7
1968	72.0	61.1	5.0	16.3	11.7	3.9	57.9	2.1	12.3	--	44.2	286.5
1969	72.5	67.0	6.4	25.9	12.8	4.3	77.3	2.2	11.7	--	44.8	324.9
1970	76.2	63.3	4.7	23.7	14.5	4.8	83.8	2.9	13.8	--	45.7	333.4
1971	83.1	64.3	4.2	25.9	15.8	5.3	97.3	3.2	17.5	--	47.3	363.9
1972	103.4	96.7	4.8	27.2	14.6	4.9	113.1	2.9	21.4	--	50.2	439.2
1973	131.7	148.4	2.1	38.9	16.0	5.3	130.5	3.7	19.3	--	56.8	552.7
1974	119.7	156.9	4.4	48.7	15.6	5.2	141.4	4.4	22.4	--	67.3	586.0
1975	118.6	160.0	13.7	49.0	19.0	6.3	169.2	5.1	21.6	--	75.4	637.9
						Region 8						
1958	27.4	40.7	1.0	2.6	1.2	.4	6.2	.3	--	.8	--	80.6
1959	27.5	24.5	1.5	2.6	1.3	.4	7.2	.3	--	.7	--	66.0
1960	21.3	26.0	1.8	3.2	1.1	.4	8.2	.3	--	1.2	--	63.5
1961	25.8	18.2	1.3	3.6	1.3	.4	8.3	.3	--	2.3	--	61.5
1962	23.3	33.6	.9	3.7	1.4	.5	8.7	.4	--	3.6	--	76.1
1963	24.7	43.2	.9	4.6	1.6	.5	9.5	.3	--	4.1	--	89.4
1964	26.3	29.9	1.6	4.9	1.9	.6	10.7	.3	--	4.0	--	80.2
1965	30.9	35.4	1.7	4.9	2.4	.8	11.2	.2	--	5.4	--	92.9
1966	35.2	46.6	1.3	5.3	3.3	1.1	12.1	.2	--	8.2	--	113.3
1967	38.3	49.0	1.3	4.0	4.0	1.3	12.1	.2	--	11.0	--	121.2
1968	38.3	36.0	1.5	6.4	5.1	1.7	13.9	.3	--	16.9	--	120.1
1969	38.6	36.7	2.2	10.2	5.5	1.8	22.3	.2	--	14.5	--	132.0
1970	38.9	42.4	2.0	9.3	6.2	2.1	29.3	.3	--	16.9	--	147.4
1971	43.8	42.5	4.1	10.2	6.8	2.3	23.1	.3	--	14.7	--	147.8
1972	58.2	64.9	1.4	10.7	6.3	2.1	23.9	.4	--	15.0	--	182.9
1973	74.7	113.6	.4	15.3	6.9	2.3	27.2	.4	--	18.1	--	258.9
1974	70.9	161.0	1.8	19.2	6.8	2.3	29.2	.5	--	37.6	--	329.3
1975	70.0	91.1	1.8	19.3	8.2	2.7	35.7	2.0	--	45.8	--	276.6

Interdependence coefficients were multiplied by the final demand vectors for each of the regions in each of the years in the manner previously described for North Dakota. The resulting estimates of personal income are shown in the first column for each region in Table 6. The U.S. Department of Commerce estimate of personal income for each region and the percentage difference in the two estimates also are presented in Table 6, as are the estimates of personal income that were derived by disaggregation procedures for each region and the difference of those estimates from the input-output based estimates.

The average differences between the estimates of personal income obtained by input-output techniques and those reported by the U.S. Department of Commerce were 23.6, 11.0, 3.8, 18.4 percent, for Regions 1, 2, 7, and 8, respectively (Table 6). The average of the average differences for the four regions was 14.2 percent. Corresponding differences of input-output estimates from those obtained by disaggregation techniques for the four regions were 11.9, 12.6, 7.4, and 14.0 percent, for an overall average difference of 11.5 percent.

Figures 3, 4, 5, and 6 provide graphic indication of the levels of personal income reported by the Department of Commerce for the four regions relative to the levels estimated by the input-output and by disaggregation techniques. Although the estimates based on input-output techniques are somewhat more volatile than the other two estimates, a consistent pattern is evident for most years. The years since 1973 appear to involve more divergence of estimates than is true for other years. This likely is due, at least in part, to the fact that some of the data are preliminary, both for the final demand vectors and the Department of Commerce estimates of personal income. These data often are revised several times during the five-year period following each year.

TABLE 6. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, BY REGION, NORTH DAKOTA, 1958-1975

Year	I-O Analysis Estimate (Mil. $)	Department of Commerce Estimate (Mil. $)	Department of Commerce Difference (%)	Disaggregation Procedure Estimate (Mil. $)	Disaggregation Procedure Difference (%)	I-O Analysis Estimate (Mil. $)	Department of Commerce Estimate (Mil. $)	Department of Commerce Difference (%)	Disaggregation Procedure Estimate (Mil. $)	Disaggregation Procedure Difference (%)
	State Region 1					State Region 2				
1958	45.0	N/A		57.5	-21.7	130.6	N/A		151.4	-13.7
1959	44.3	70.0	-36.7	54.6	-18.9	131.0	138.2	-5.2	150.2	-12.8
1960	50.3	N/A		59.7	-15.7	138.2	N/A		170.0	-18.7
1961	44.7	N/A		51.8	-13.7	124.9	N/A		152.6	-18.2
1962	64.7	83.1	-22.1	74.6	-13.3	244.4	213.2	+14.6	227.3	+7.5
1963	74.8	N/A		70.3	+6.4	236.2	N/A		212.8	+11.0
1964	70.5	N/A		64.6	+9.1	310.4	N/A		216.6	+43.3
1965	72.8	76.6	-5.0	72.9	-0.1	236.6	246.9	-4.2	249.8	-5.3
1966	83.3	78.8	+5.7	74.9	+11.2	287.8	255.9	+12.5	270.9	+6.2
1967	77.4	79.6	-2.8	73.0	+6.0	226.1	265.9	-15.0	274.4	-17.6
1968	78.2	78.8	-0.8	73.5	+6.4	262.8	276.3	-4.9	287.6	-8.6
1969	102.9	87.6	+17.5	88.2	+16.7	309.7	297.9	+4.0	325.3	-4.8
1970	99.0	84.7	+16.9	87.2	+13.5	355.1	302.3	+17.5	339.7	+4.5
1971	105.8	82.2	+28.7	95.3	+11.0	367.9	327.8	+12.2	378.8	-2.9
1972	134.9	102.5	+31.6	119.8	+12.6	395.9	373.9	+5.9	436.7	-9.3
1973	199.9	140.2	+42.6	203.6	-1.8	628.6	560.8	+12.1	642.5	-2.2
1974	225.9	130.7	+72.8	182.9	+23.5	676.1	545.7	+23.9	603.9	+12.0
1975	195.4	N/A		172.7	+13.1	773.6	N/A		601.0	+28.7
Average Dif.[a]			23.6		11.9			11.0		12.6
	State Region 7					State Region 8				
1958	159.6	N/A		157.5	+1.3	81.4	N/A		74.0	+10.0
1959	144.1	135.8	+6.1	142.0	+1.5	67.8	59.4	+14.1	58.9	+15.1
1960	148.2	N/A		163.5	-9.4	65.0	N/A		68.2	-4.7
1961	135.8	N/A		144.2	-5.8	62.8	N/A		56.0	+12.1
1962	189.3	179.1	+5.7	217.5	-13.0	76.0	83.8	-9.3	88.5	-14.1
1963	187.2	N/A		196.6	-4.8	88.9	N/A		82.2	+7.6
1964	210.9	N/A		201.2	+4.8	80.4	N/A		75.9	+5.9
1965	216.6	231.6	-6.5	233.1	-7.1	92.2	91.8	+0.4	91.3	+0.1
1966	245.5	243.0	+1.0	239.5	+2.5	110.3	95.3	+15.7	97.4	+13.2
1967	236.8	250.6	-5.5	239.9	-1.3	116.2	95.5	+21.7	101.0	+15.0
1968	257.4	259.6	-0.8	249.6	+3.1	111.2	95.8	+16.1	95.8	+16.1
1969	302.7	298.5	+1.4	277.6	+9.0	128.0	114.0	+12.3	107.8	+18.7
1970	312.7	315.8	-1.0	284.8	+9.8	145.2	116.0	+25.2	107.9	+34.6
1971	346.0	346.5	-0.1	325.0	+6.5	142.5	123.5	+15.4	126.7	+12.5
1972	425.3	409.0	+4.0	377.7	+12.6	178.9	151.0	+18.5	154.5	+15.8
1973	530.3	516.8	+4.5	495.2	+7.1	252.6	220.0	+14.8	234.7	+7.6
1974	564.3	515.3	+9.5	481.9	+17.1	307.7	195.5	+57.4	236.3	+30.2
1975	618.2	N/A		530.0	+16.6	254.0	N/A		213.6	+18.9
Average Dif.[a]			3.8		7.4			18.4		14.0

[a]Without respect to sign.

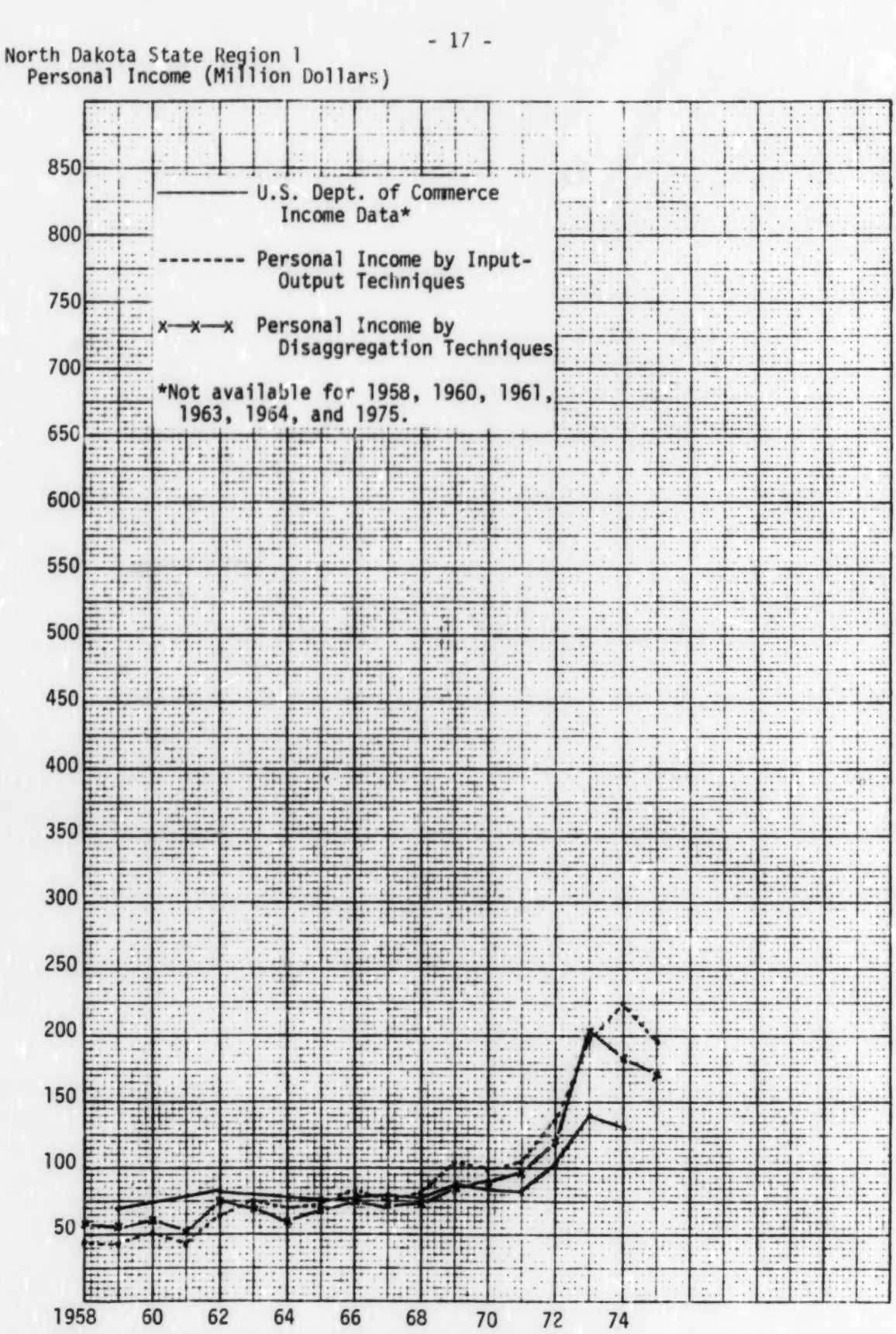


Figure 3. Personal Income in Region 1, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975.

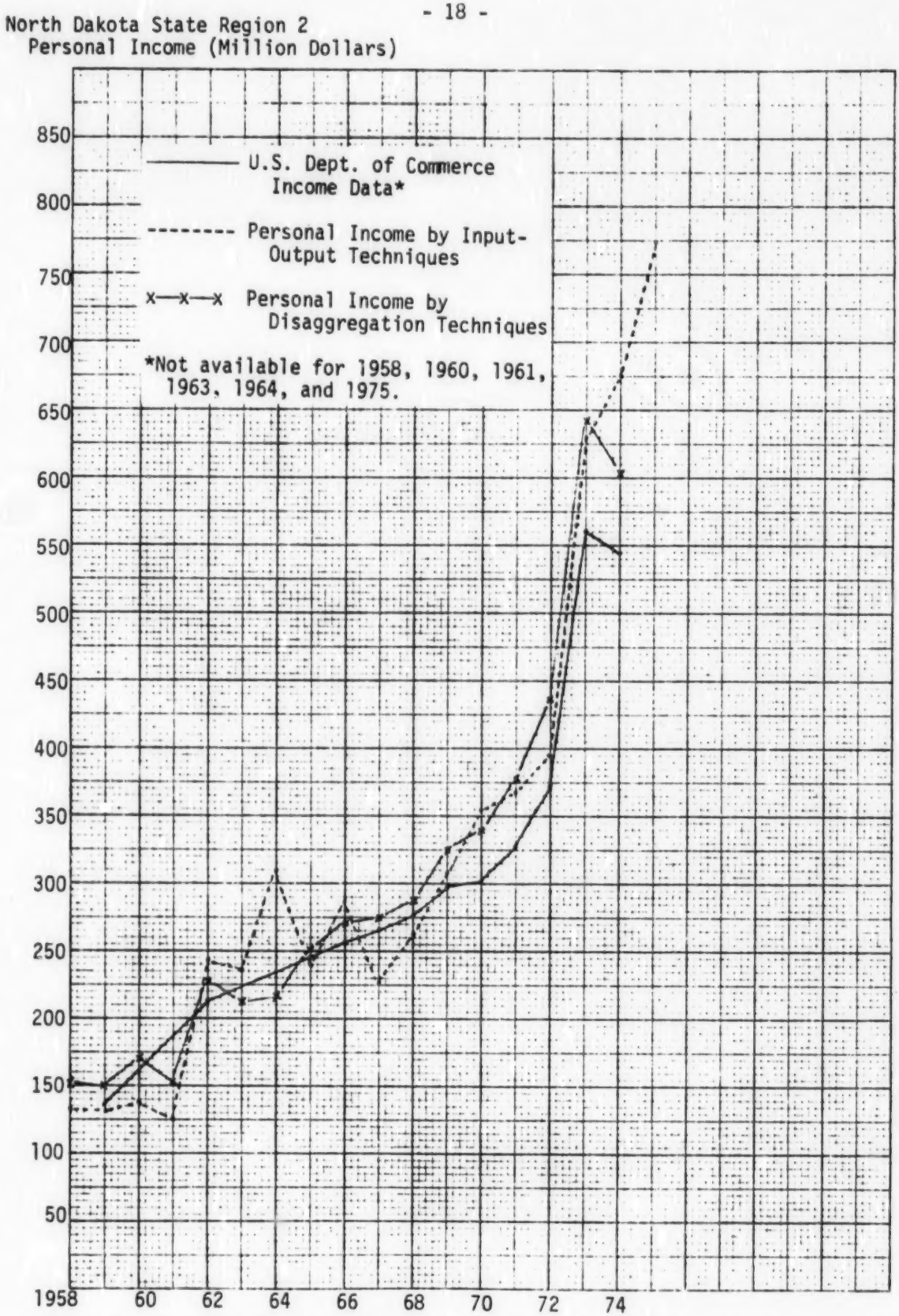


Figure 4. Personal Income in Region 2, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975.

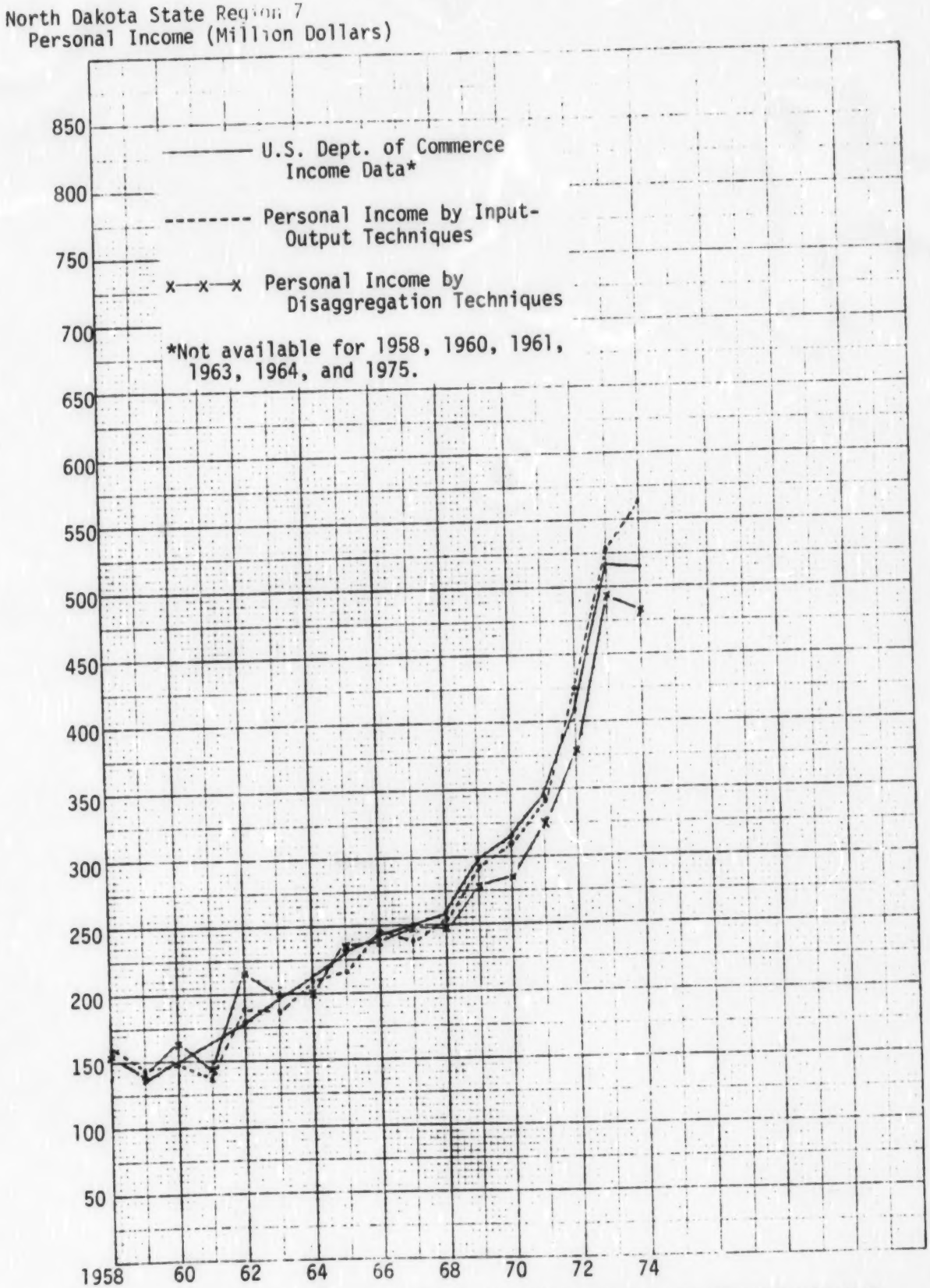


Figure 5. Personal Income in Region 7, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975.

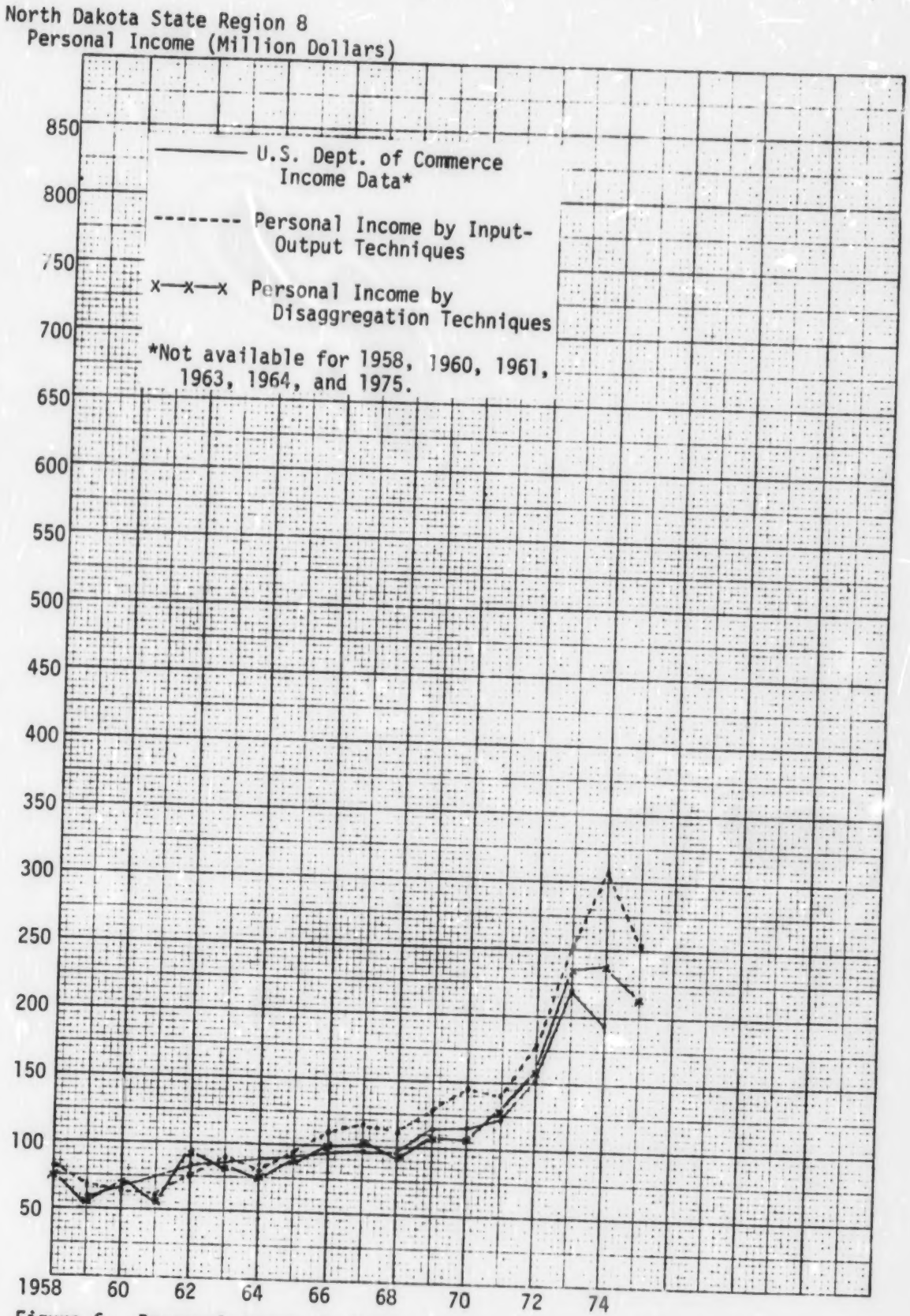


Figure 6. Personal Income in Region 8, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975.

Montana

The area in Montana that was of particular interest in this study was a nine-county area in southeastern Montana (Figure 7). Personal income estimates were made by input-output techniques for that region and for the state of Montana. Disaggregation procedures also were used to estimate personal income in the region. The procedures used were identical to those used for North Dakota and North Dakota's regions. Estimates of final demand vectors for the state and region for the years 1958-1975 are presented in Table 7. The resulting estimates of personal income for Montana and southeastern Montana are presented in Table 8 and in Figures 8 and 9.

Input-output techniques appear to have a significant downward bias, both at the state level and at the regional level. The state level estimate obtained by input-output analysis averages about 25 percent less than that reported by the U.S. Department of Commerce and the corresponding difference for the region is about 27 percent. Disaggregation procedures for deriving estimates of personal income in the nine southeastern Montana counties provided estimates that were consistently less than the Department of Commerce estimates for the years prior to 1973. However estimates based on disaggregation procedures rose rapidly in recent years so input-output based estimates averaged 27 percent below those obtained by disaggregation procedures also. However, both the state and the regional estimates based on input-output analysis differ from the Department of Commerce estimates by a rather consistent amount in the respective years.

Wyoming

Eight counties in northeastern Wyoming (Figure 10) were regarded as a region that could be impacted by coal development. The final demand

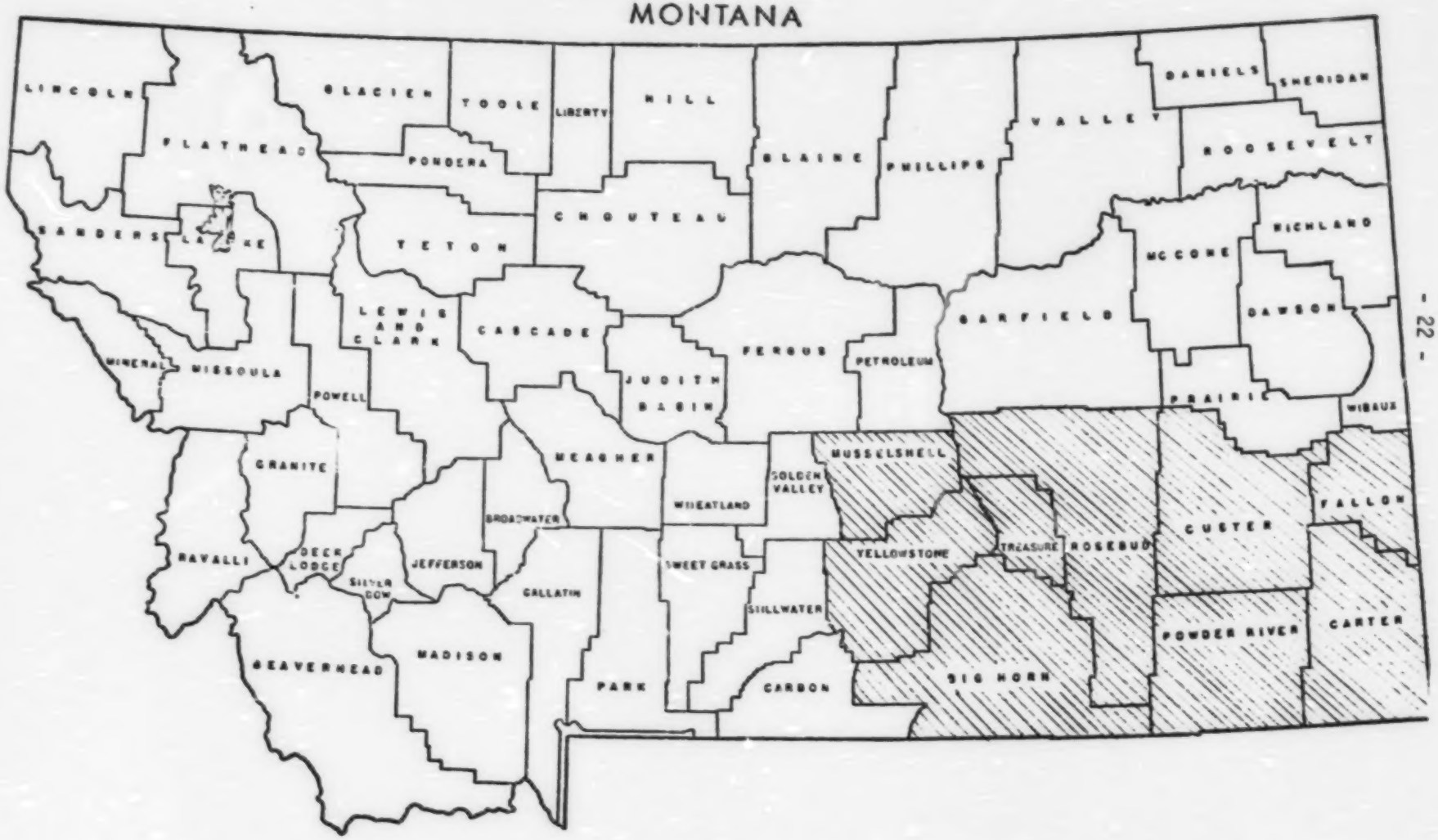


Figure 7. Montana and Nine-County Region in Southeastern Montana.

TABLE 7. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, MONTANA AND SOUTHEASTERN MONTANA, 1958-1975 (MILLION DOLLARS)

Year	(A) Agriculture, Livestock	(B) Agriculture, Crops	(C) Contract Construction	(D) Wholesale Trade & Ag Processing	(E) Retail Trade	(F) Business & Personal Service	(G) Households	(H) Coal Mining	(I) Electric Generating	(J) Petroleum/ Natural Gas Extraction	(K) Petroleum Refining	(L) Total
						Montana						
1958	240.5	220.4	16.9	58.1	36.8	12.3	218.4	1.2	--	--	36.3	840.9
1959	215.8	203.0	31.3	62.3	39.8	13.3	246.6	1.0	--	--	40.1	853.2
1960	222.1	200.9	30.7	63.4	44.3	14.8	268.3	.7	--	--	37.9	883.1
1961	215.2	167.1	30.9	67.3	52.2	17.4	365.9	.6	--	--	35.8	952.4
1962	205.9	226.7	33.9	65.8	60.1	20.0	317.2	.5	--	--	42.1	972.2
1963	185.8	244.3	42.4	67.0	68.0	22.7	390.5	.4	--	--	41.6	1,062.7
1964	201.8	225.1	52.0	69.7	75.9	25.3	342.2	.3	--	--	47.2	1,039.5
1965	243.9	228.2	59.1	74.0	83.8	27.9	418.2	.4	--	--	50.8	1,186.3
1966	289.2	282.8	51.6	79.3	91.7	30.6	395.2	.6	--	--	52.2	1,273.2
1967	267.2	289.9	52.6	80.6	99.6	33.2	493.0	.3	--	--	58.1	1,374.5
1968	319.4	258.3	57.7	84.0	122.5	40.8	570.8	.5	--	--	64.7	1,518.7
1969	352.7	261.5	75.9	91.0	135.1	45.0	578.6	1.4	--	--	62.9	1,604.1
1970	355.9	329.3	79.3	98.2	148.5	49.5	625.5	5.1	--	--	69.8	1,681.8
1971	408.6	303.0	82.6	104.7	157.8	52.6	672.4	12.1	--	--	79.7	1,873.5
1972	495.4	431.6	254.5	109.8	173.6	57.9	709.3	15.9	--	--	96.9	2,344.9
1973	564.0	575.1	58.0	129.9	187.0	62.2	823.2	29.5	--	--	108.2	2,537.1
1974	433.1	769.9	68.3	152.9	200.4	66.5	914.3	43.0	--	--	116.0	2,764.4
1975	420.7	667.0	128.3	175.2	213.8	70.8	1,023.3	56.5	--	--	123.8	2,879.4
						Southeastern Montana						
1958	52.6	36.8	3.7	18.7	7.1	2.4	34.2	1.2	--	--	17.9	174.6
1959	50.2	25.2	6.8	19.9	7.6	2.6	38.6	1.0	--	--	50.2	202.1
1960	49.0	24.8	6.7	20.0	8.5	2.8	42.0	.7	--	--	47.3	201.8
1961	43.0	20.3	6.8	20.9	10.0	3.3	57.3	.6	--	--	45.5	207.7
1962	38.1	26.5	7.5	20.1	11.5	3.8	49.7	.5	--	--	54.1	211.8
1963	35.3	33.3	9.3	19.8	13.1	4.4	61.1	.4	--	--	52.9	229.6
1964	42.3	31.0	11.4	20.2	14.6	4.9	53.6	.3	--	--	62.9	241.2
1965	51.7	26.3	13.0	21.1	16.1	5.4	65.5	.4	--	--	66.0	265.5
1966	61.2	31.1	11.3	22.2	17.6	5.9	61.9	.6	--	--	67.8	279.6
1967	55.6	35.2	11.6	22.2	19.1	6.4	77.2	.3	--	--	75.7	303.3
1968	62.4	33.9	12.3	23.1	23.5	7.8	83.2	.5	--	--	84.6	331.3
1969	71.6	33.6	11.5	25.5	25.9	8.6	91.6	1.4	--	--	82.6	352.3
1970	80.6	38.0	17.4	28.0	28.5	9.5	96.5	5.1	--	--	91.6	395.2
1971	90.3	32.6	23.4	30.4	30.3	10.1	101.5	12.1	--	--	104.9	435.6
1972	115.2	43.4	3.5	31.9	33.3	11.1	108.2	15.9	--	--	129.3	491.8
1973	122.0	58.8	20.3	37.7	35.9	11.9	128.5	29.5	--	--	143.6	588.2
1974	107.1	90.0	12.5	44.3	38.5	12.8	160.5	43.0	--	--	152.4	661.1
1975	94.8	64.6	25.4	60.0	41.0	13.6	160.8	56.5	--	--	161.2	677.9

TABLE 8. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, MONTANA AND MONTANA REGION, 1958-1975

	Montana			Southeast Montana Region				
	I-O Analysis Estimate	Dept. of Commerce		I-O Analysis Estimate	Dept. of Commerce		Disaggregation Procedure	
Year	(Mil. $)	Estimate (Mil. $)	Difference (%)	(Mil. $)	Estimate (Mil. $)	Difference (%)	Estimate (Mil. $)	Difference (%)
1958	894.2	1,354.0	-34.0	171.2	N/A		260.7	-34.3
1959	910.3	1,345.2	-32.3	176.9	272.3	-35.0	262.4	-32.6
1960	951.1	1,382.0	-31.2	180.0	N/A		266.5	-32.5
1961	1,070.4	1,369.0	-21.8	194.3	N/A		264.3	-26.5
1962	1,050.0	1,580.0	-33.5	186.6	296.9	-37.2	288.2	-35.3
1963	1,170.8	1,588.0	-26.3	209.4	N/A		300.1	-30.2
1964	1,108.6	1,595.0	-30.5	208.3	N/A		303.9	-31.5
1965	1,287.5	1,724.7	-25.3	235.7	327.5	-28.0	325.2	-27.5
1966	1,357.1	1,872.7	-27.5	246.1	352.5	-30.2	348.2	-29.3
1967	1,501.0	1,924.7	-22.0	271.3	370.0	-26.7	362.5	-25.2
1968	1,668.4	2,033.2	-17.9	293.1	401.8	-27.1	386.6	-24.2
1969	1,743.2	2,203.1	-20.9	318.4	423.5	-24.8	417.9	-23.8
1970	1,905.5	2,442.7	-22.0	352.1	470.5	-25.2	464.7	-24.2
1971	2,028.8	2,539.0	-21.9	380.1	500.9	-24.1	490.9	-22.6
1972	2,427.3	2,914.0	-16.7	427.6	567.3	-24.6	556.5	-23.1
1973	2,731.2	3,460.1	-21.1	510.8	644.6	-20.8	648.5	-21.2
1974	2,967.7	3,643.7	-18.6	588.7	687.8	-14.4	713.4	-17.5
1975	3,098.6	4,054.0	-23.6	585.2	N/A		776.3	-24.6
Average Dif.			24.8			26.5		27.0

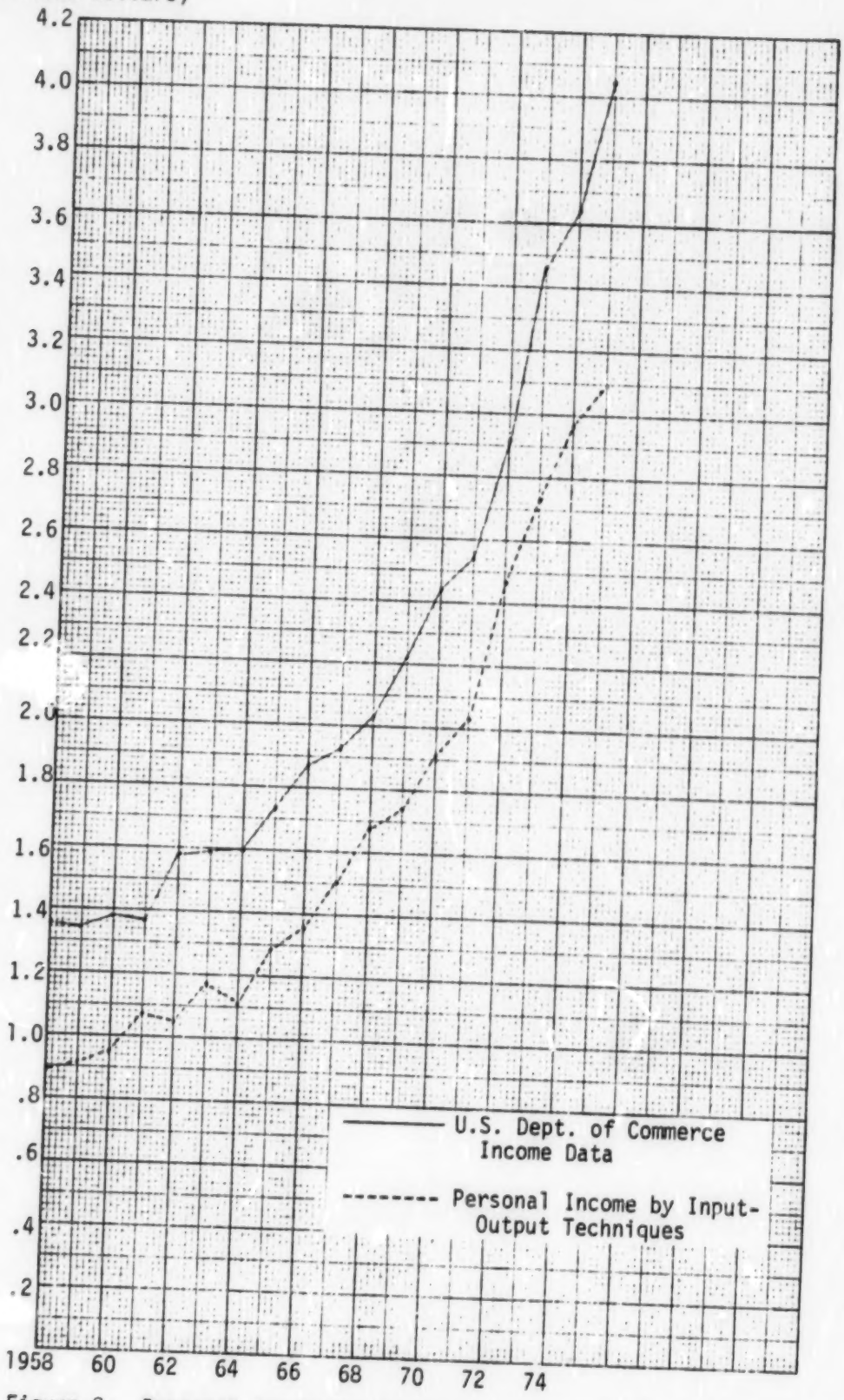


Figure 8. Personal Income in Montana, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975.

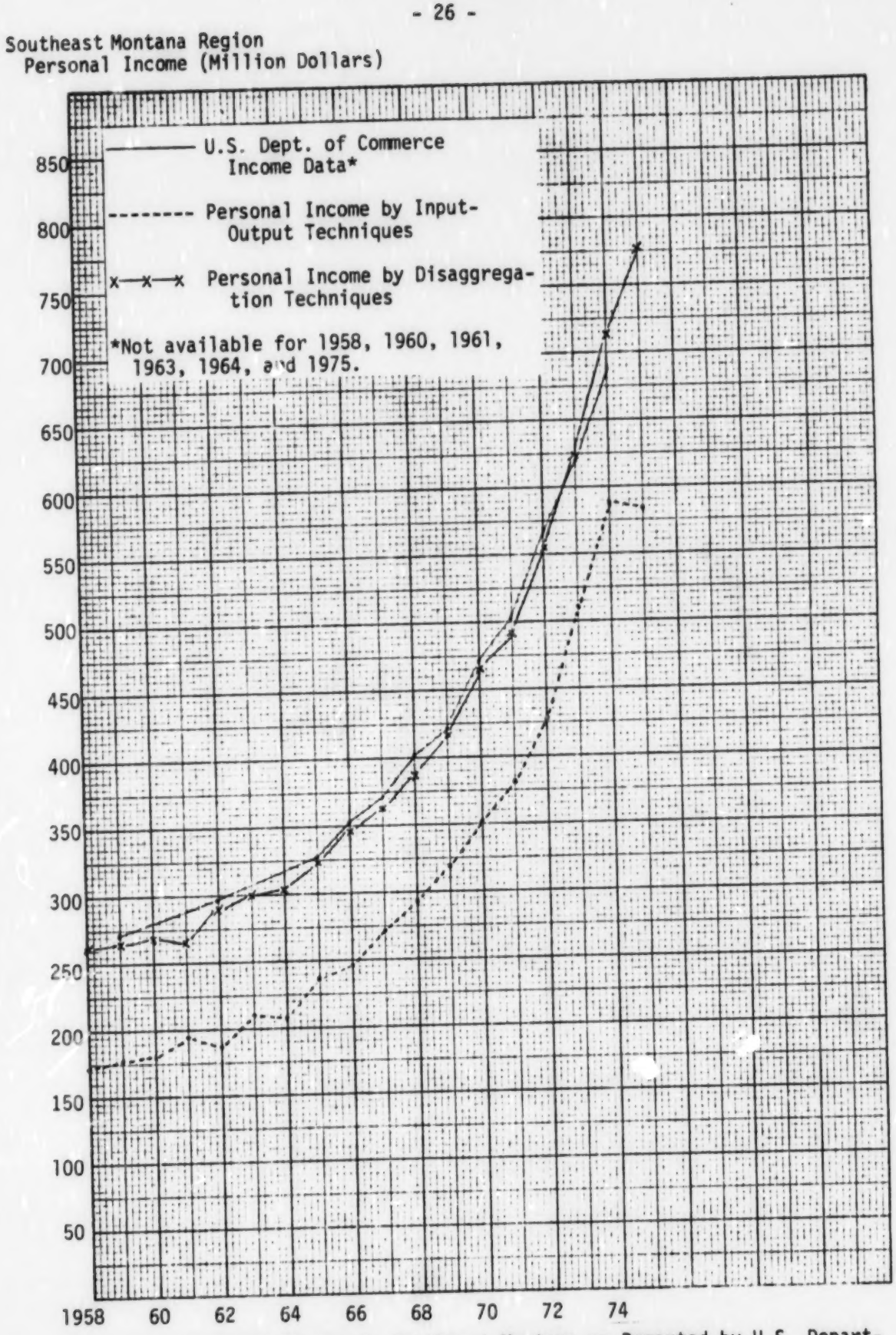
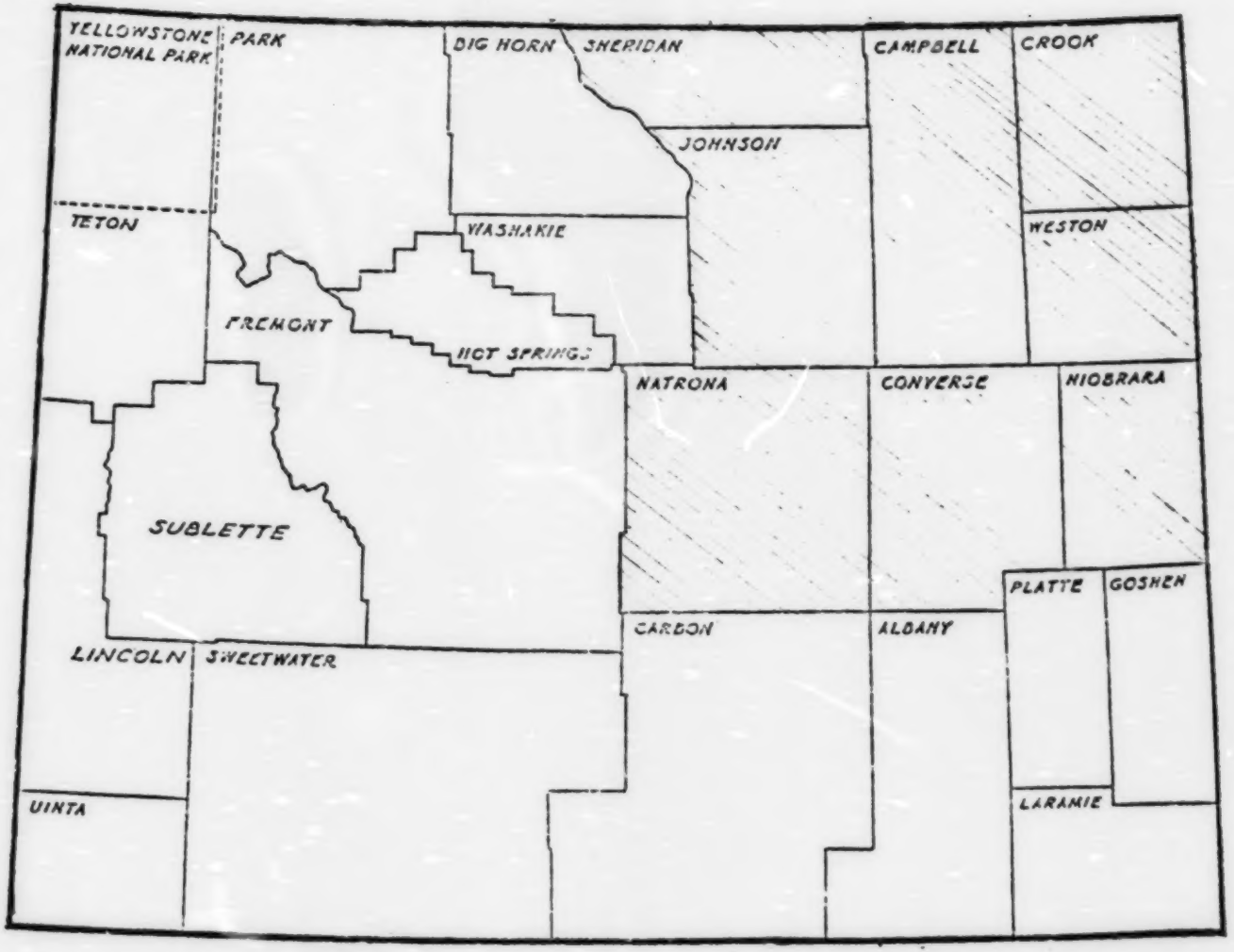


Figure 9. Personal Income in Southeast Montana as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques. 1958-1975.



WYOMING

Figure 10. Wyoming and Eight-County Region in Northeastern Wyoming.

vectors that were assembled for that region and for the state of Wyoming are presented in Table 9. Procedures for using input-output analysis to estimate personal income in Wyoming were the same as for North Dakota and Montana. The same procedures used in disaggregating personal income to the county level for North Dakota and Montana also were used for Wyoming. Estimates of personal income obtained by input-output procedures were expressed as percentage differences from Department of Commerce estimates at the state and regional level (Table 10). Similar comparisons were made at the regional level of input-output based estimates and those obtained by disaggregation procedures. Input-output estimates of personal income averaged about 15 percent less than Department of Commerce estimates at the state level and 22 percent less at the regional level. Input-output estimates of regional personal income averaged 19.5 percent less than those obtained by disaggregation procedures.

As was true for North Dakota and Montana, the input-output based personal income estimates for Wyoming (Figure 11) and northeastern Wyoming (Figure 12) are somewhat more erratic than the other types of estimates. However, except for the years since 1973, the three types of estimates parallel each other rather consistently. As is likely for the other two states, divergence in recent years may be reduced as preliminary data are revised by state and federal agencies.

CONCLUSIONS

The results of the work conducted under Phase I of this study indicate that the input-output coefficients developed for North Dakota provide satisfactory estimates of personal income in the four western regions of North Dakota. The 17 sector model (which includes coefficients collected in

TABLE 9. SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, WYOMING AND NORTHEASTERN WYOMING, 1958-1975 (MILLION DOLLARS)

Year	(A) Agriculture, Livestock	(B) Agriculture, Crops	(C) Contract Construction	(D) Wholesale Trade & Ag Processing	(E) Retail Trade	(F) Business & Personal Service	(G) Households	(H) Coal Mining	(I) Electric Generating	(J) Petroleum/ Natural Gas Extraction	(K) Petroleum Refining	Total
						Wyoming						
1958	135.4	38.7	20.2	22.9	26.3	8.9	155.7	3.0	14.2	212.2	87.0	724.5
1959	135.2	44.2	29.1	25.2	27.0	9.0	172.6	3.5	13.8	222.7	92.8	775.1
1960	129.2	37.9	26.1	26.2	28.1	9.4	182.4	3.6	13.5	234.7	95.6	786.7
1961	123.6	38.5	25.8	27.0	37.8	12.6	172.1	4.7	12.0	253.6	103.8	811.5
1962	122.6	33.7	27.8	28.2	47.5	15.8	181.8	3.9	10.5	243.3	110.1	825.2
1963	128.1	44.0	38.9	24.2	57.2	19.1	303.2	4.9	9.0	245.5	109.9	984.0
1964	125.0	40.7	36.5	27.3	67.0	22.3	237.7	3.9	7.5	250.1	97.4	915.4
1965	145.1	35.2	48.3	26.3	76.7	25.6	210.7	3.3	6.0	249.0	103.6	929.8
1966	174.6	44.8	38.3	28.2	86.4	28.8	224.3	4.1	8.3	243.8	106.2	987.8
1967	161.4	47.0	37.3	29.1	96.1	32.0	250.7	3.3	9.9	250.3	100.6	1,017.7
1968	186.0	50.8	41.5	31.4	105.8	35.3	276.4	3.2	12.6	269.8	110.7	1,123.5
1969	199.4	50.9	38.8	34.9	115.6	38.5	298.7	3.7	14.4	300.2	117.3	1,212.4
1970	195.6	52.8	37.3	38.4	125.3	41.8	306.6	13.1	16.2	306.0	127.7	1,260.8
1971	218.0	56.9	35.8	40.8	135.0	45.0	314.5	14.9	15.0	312.7	140.2	1,328.8
1972	281.8	74.4	44.9	42.0	144.7	48.2	349.0	21.3	22.8	352.6	158.3	1,540.0
1973	328.6	79.9	32.9	49.3	155.9	52.0	568.8	31.7	27.9	405.6	174.4	1,907.0
1974	235.5	122.6	30.6	64.9	165.1	55.2	456.8	38.6	33.9	446.3	189.6	1,839.1
1975	250.3	101.5	96.8	71.0	177.4	59.1	505.9	45.8	38.7	488.5	202.3	2,037.3
						Northeastern Wyoming						
1958	52.3	4.9	7.4	10.3	8.2	2.8	36.4	1.5	10.2	59.6	52.0	245.6
1959	52.5	5.4	10.6	11.1	8.4	2.8	40.3	2.3	9.8	65.1	55.7	264.0
1960	48.5	4.2	9.5	11.4	8.7	2.9	42.6	2.4	9.5	69.9	57.4	267.0
1961	47.7	3.3	9.4	11.6	11.7	3.9	110.2	2.8	8.4	72.7	62.3	274.0
1962	43.5	5.6	10.2	12.0	14.7	4.9	42.5	3.0	7.4	69.1	66.1	279.0
1963	47.2	6.7	14.2	10.2	17.7	5.9	70.9	3.3	6.3	73.6	65.8	321.8
1964	46.7	5.4	13.3	11.5	20.8	6.9	55.6	3.7	5.3	80.8	58.4	308.4
1965	54.2	5.1	17.6	10.9	23.8	7.9	49.2	3.8	4.2	85.6	62.2	324.5
1966	64.8	5.4	14.0	11.6	26.8	8.9	52.4	4.2	5.8	86.6	63.7	344.2
1967	57.5	6.8	13.6	12.0	29.8	9.9	58.6	4.3	6.8	89.4	60.4	349.1
1968	68.6	5.3	11.8	14.1	32.8	10.9	68.5	4.4	8.8	97.9	66.4	389.5
1969	73.4	5.5	14.8	17.4	35.8	11.9	73.8	4.5	10.1	117.3	70.4	434.9
1970	73.0	5.9	13.5	21.1	38.8	13.0	72.8	6.6	11.3	140.1	76.6	472.7
1971	80.9	5.8	12.9	24.5	41.9	14.0	71.7	7.0	10.5	143.3	84.1	496.6
1972	105.0	8.2	19.9	26.9	44.9	14.9	79.3	8.0	15.9	162.0	95.0	580.0
1973	126.9	10.5	12.0	31.5	48.3	16.1	120.6	10.6	18.6	186.8	104.6	686.5
1974	90.8	10.4	11.4	41.6	51.2	17.1	102.8	12.8	22.4	198.3	112.8	671.6
1975	96.5	9.1	34.2	45.4	55.0	18.3	126.0	14.9	25.3	211.5	122.1	758.3

TABLE 10. ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, WYOMING AND WYOMING REGION, 1958-1975

Year	Wyoming			Northeast Wyoming Region				
	I-O Analysis Estimate (Mil. $)	Dept. of Commerce Estimate (Mil. $)	Dept. of Commerce Difference (%)	I-O Analysis Estimate (Mil. $)	Dept. of Commerce Estimate (Mil. $)	Dept. of Commerce Difference (%)	Disaggregation Procedure Estimate (Mil. $)	Disaggregation Procedure Difference (%)
1958	569.2	668.0	-14.8	173.3	N/A		216.5	-20.0
1959	613.4	723.3	-15.2	186.0	257.5	-27.8	231.2	-19.5
1960	620.6	744.0	-16.6	185.9	N/A		240.0	-22.5
1961	614.6	774.0	-20.6	184.7	N/A		249.3	-25.9
1962	629.7	802.9	-21.6	188.5	276.7	-31.9	255.6	-26.3
1963	844.5	819.0	-3.1	241.6	N/A		260.8	-7.4
1964	740.1	832.0	-11.0	218.5	N/A		261.4	-16.4
1965	727.1	863.0	-15.7	222.5	297.6	-25.2	269.8	-17.5
1966	790.5	898.7	-12.0	240.8	302.4	-20.4	279.8	-13.9
1967	826.6	946.5	-12.7	246.5	306.4	-19.5	289.5	-14.9
1968	916.8	1,010.9	-9.3	279.9	341.1	-17.9	315.2	-11.2
1969	985.6	1,123.8	-12.3	307.7	388.1	-20.7	356.2	-13.6
1970	1,015.7	1,272.9	-20.2	321.2	428.0	-25.0	407.5	-21.2
1971	1,069.1	1,313.0	-18.6	335.1	434.4	-22.9	417.6	-19.8
1972	1,244.4	1,479.6	-15.9	394.5	486.0	-18.8	479.6	-17.7
1973	1,676.3	1,725.7	-2.9	498.3	545.7	-8.7	572.0	-12.9
1974	1,487.6	1,941.4	-23.4	451.4	606.6	-25.6	694.4	-35.0
1975	1,635.8	2,294.0	-28.7	520.9	N/A		806.2	-35.4
Average Dif.			15.3			22.0		19.5

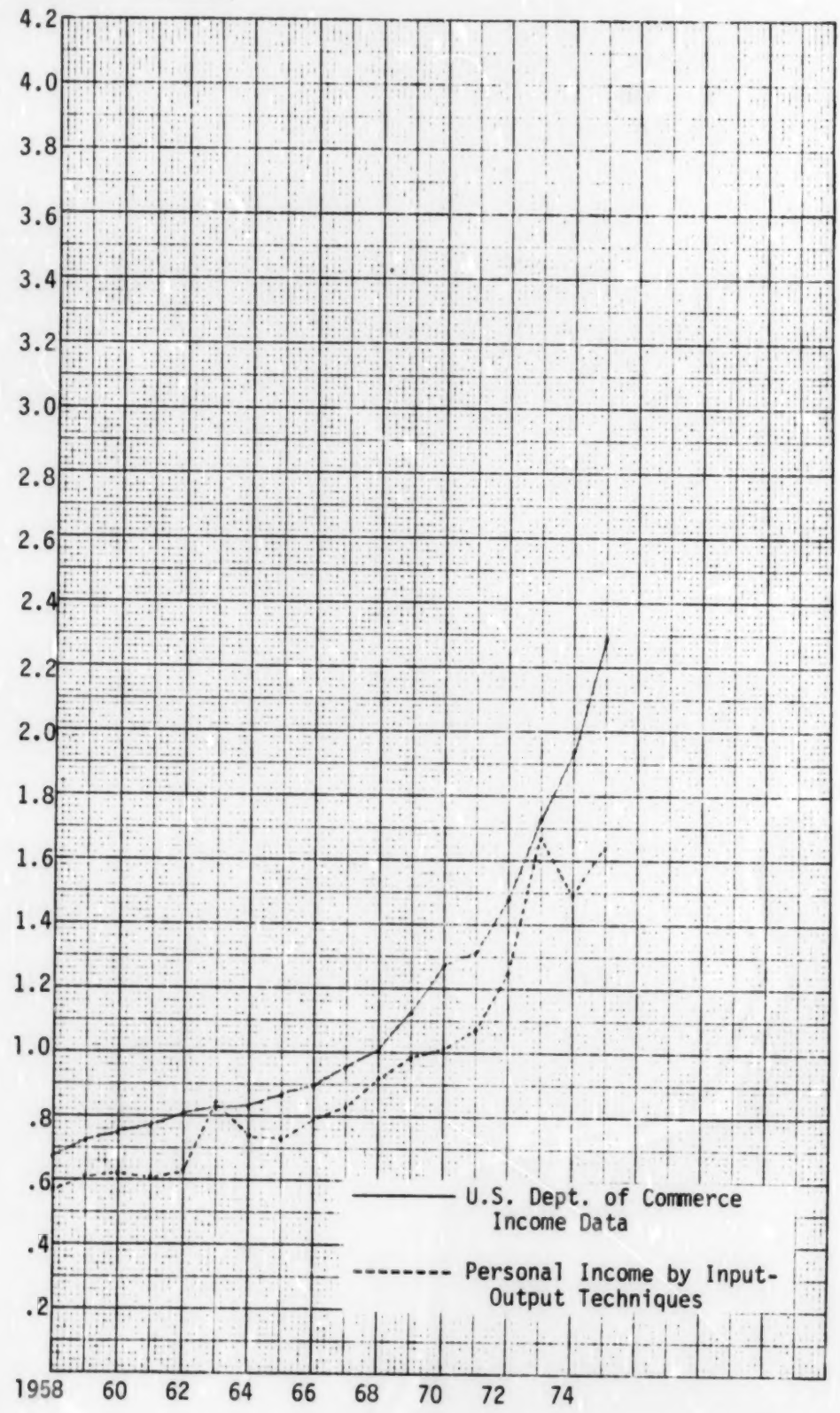


Figure 11. Personal Income in Wyoming, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975.

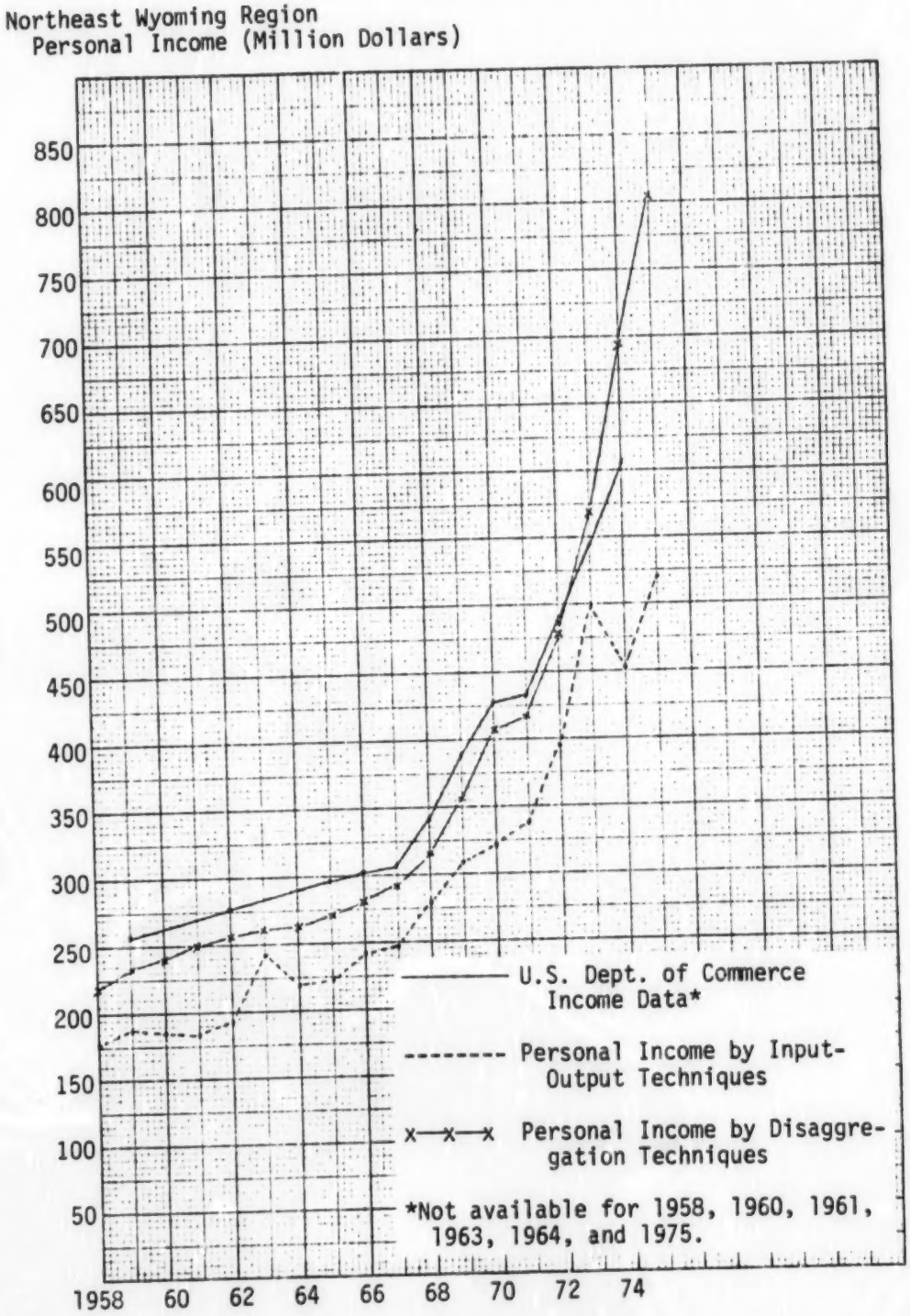


Figure 12. Personal Income in Northeast Wyoming, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975.

Phase I for the coal mining, coal fired thermal electric generating, petroleum and natural gas extraction, and petroleum refining sectors) provides personal income estimates that coincide more closely with Department of Commerce estimates than do those obtained with the earlier 13 sector model. It appears that the input-output model can be used for estimating the potential effects of coal resource development in North Dakota.

The model does not perform as well for northeastern Wyoming and southeastern Montana as in North Dakota. It appears to provide estimates that consistently underestimate personal income in Montana and Wyoming. The downward bias of the estimates at the state level for the two states may be partially due to the fact that the 17 sector model does not include some sectors (such as metalic mining and forestry) for those states. Some of the differences between input-output estimates of personal income and Department of Commerce estimates for the study regions in the two states may be due to an upward bias in Department of Commerce estimates. However, procedures employed in this study to disaggregate state level personal income yielded results that suggest that the upward bias in Department of Commerce estimates is not great.

The fact the input-output model invariably underestimates personal in Montana and Wyoming implies that the model leaves something to be desired for describing the level of economic activity in those states. However, the model does provide estimates that appear to "track" quite consistently with Department of Commerce data, but with a predictable downward bias. The rather constant downward bias in the historical comparison may allow the model to be used for impact analysis of coal resource development in the two states. In other words, even though the model

underestimates personal income throughout the historical comparison period, year-to-year changes estimated by the model compare quite favorably with those reported by the Department of Commerce.

RECOMMENDATIONS FOR FURTHER WORK

It is not recommended that work be initiated on Phase II at this time. The reason is that some additional work similar to that envisioned for Phase II will be conducted at North Dakota State University later in 1977. Part of this work includes modifying the input-output technical coefficients with location coefficients (that reflect industry mix) for the respective region in the three states. It is possible that the bias of the input-output model (which appears to be related to population density of the regions) may be reduced by this procedure.

Additional work is also scheduled under an agreement with the North Dakota Regional Environmental Assessment Program (REAP). This will involve expansion and refinement of the REAP Economic-Demographic Model. The results of this work will provide measures of the reliability of the model for projecting personal income, employment, and population (and also other variables) in each of the eight regions in North Dakota. Since the inter-dependence coefficients are an integral component of this model, that work will contribute information regarding the usefulness of those coefficients for evaluating impacts of coal resource development in North Dakota, Montana, and Wyoming.

If the results of those efforts warrant it, further consideration can be given to implementation of Phase III of this project.

APPENDIX A

PROCEDURES AND DATA SOURCES FOR ESTIMATING FINAL DEMAND VECTORS

The economic base for North Dakota and eastern Montana and Wyoming consists almost entirely of receipts of 11 basic sectors. These sectors are: agriculture, livestock; agriculture, crops; construction; wholesale trade and agricultural processing; retail trade: business and personal service; households; coal mining; thermal-electric generation; petroleum/natural gas exploration/extraction; and petroleum refining. [The Standard Industrial Classification (SIC) Code description for each of the 17 sectors involved in the input-output model are presented in Table 1 of the report.]

The sectors included as final demand vectors in input-output analysis are referred to as "basic sectors" because they constitute the economic base of the area. Sales by these sectors typically are the sources of income from outside the area that generate gross business volume, not only to the basic sectors, but to the other trade and service sectors within the local economy. These sectors are the ones through which income is injected into the area as purchases of agricultural, mine, or manufactured products; by the federal government for construction or for payrolls; and by tourist expenditures to the retail trade or business and personal service sectors.

Data were collected for North Dakota, Montana, and Wyoming at the state and county levels. County data were necessary because counties then were grouped together to form regions. North Dakota State Regions 1, 2, 7, and 8, nine southeastern Montana counties (Big Horn, Carter, Custer, Fallon, Musselshell, Powder River, Rosebud, Treasure, and Yellowstone), and eight counties in northeastern Wyoming (Campbell, Crook, Converse, Johnson, Natrona, Niobrara, Sheridan, and Weston) were considered in the study. The

sources of data for the three states came from identical or similar sources and the methodology involved in calculating the sales for final demand for the states were the same.

Agriculture, Livestock (Sector 1)

The data for agriculture, livestock consists of total receipts from sales of livestock and livestock products. These data were published every year from 1958 to 1975 at the county and state level for Montana,[1] but only at the state level for North Dakota[2] and Wyoming.[3] The Montana Region final demand vector was obtained by adding livestock sales receipts in the nine counties in the region. North Dakota and Wyoming livestock final demand vectors were obtained by allocating state livestock receipts to the regions. This was done by multiplying production at the county level by price for the major livestock enterprises. The allocator for the region was the share of state total product that was accounted for by counties in the study region.

Agriculture, Crops (Sector 2)

The total receipts and government payments for crops comprised the agriculture, crops final demand vector. These data were published annually for Montana[4] at the county and state level, but only at the state level for

---

[1] Montana Agricultural Statistics, Montana Department of Agriculture cooperating with U.S. Department of Agriculture, Statistical Reporting Service, Helena, Montana, December, 1962, 1964, 1968, 1970, 1974, and 1976.

[2] North Dakota Crop and Livestock Statistics, North Dakota State University, Agricultural Experiment Station, cooperating with U.S. Department of Agriculture, Statistical Reporting Service, Fargo, North Dakota, May, 1960-1976.

[3] Wyoming Agricultural Statistics, Wyoming Crop and Livestock Reporting Service, issued by Wyoming Department of Agriculture, the University of Wyoming, and U.S. Department of Agriculture, Statistical Reporting Service, Cheyenne, Wyoming, 1960-1976.

[4] Montana Agricultural Statistics, op. cit.

North Dakota[5] and Wyoming.[6] The crops total receipts and the government payments for each county in the region were added to obtain the region final demand vector for Montana. The state crop receipts and government payments were allocated to the regions for North Dakota and Wyoming in the same method as were livestock receipts. The major crop enterprises were used to allocate total crop receipts to the regions, then government payments were allocated to the regions in the same proportion that crop receipts were allocated to each respective region.

Construction (Sector 4)

The construction industry generates dollar volumes basically in the form of highway construction funded by federal government revenues. The amount of federal expenditures for highway construction for North Dakota, Montana, and Wyoming was available at the state level for the years 1958-1968.[7] The reporting procedure for these data changed in 1967 and actual federal expenditures for North Dakota,[8] Montana,[9] and Wyoming[10] were available at county and state level. Federal government outlays for construction in the respective regions for the years 1958-1966 were estimated by allocating state totals on the basis of regional shares reported for the years 1967-1975.

---

[5] North Dakota Crop and Livestock Statistics, op. cit.

[6] Wyoming Agricultural Statistics, op. cit.

[7] U.S. Treasury Department, Annual Report of the Secretary of the Treasury on the State of the Finances, 1960-1968, U.S. Government Printing Office, Washington, D.C.

[8] U.S. Department of Commerce, Federal Outlays in North Dakota, Office of Economic Opportunity, National Technical Information Service, Washington, D.C., 1967-1975.

[9] U.S. Department of Commerce, Federal Outlays in Montana, Office of Economic Opportunity, National Technical Information Service, Washington, D.C., 1967-1975.

[10] U.S. Department of Commerce, Federal Outlays in Wyoming, Office of Economic Opportunity, National Technical Information Service, Washington, D.C., 1967-1975.

Wholesale Trade and Agricultural Processing (Sector 7)

Gross output of the wholesale and agricultural processing sector consists principally of the value of miscellaneous manufacturing, much of which is food processing. Also included are rather insignificant levels of wholesaling activities, if that activity exceeds that of the benchmark region (Region 8 in North Dakota). Several sources provided the data for these estimates.[11, 12, 13, 14, 15]

Retail (Sector 8)

Final demand vectors for the retail trade sector consist of three fourths of the dollar volumes of tourism expenditures in the area. (The other one-fourth is assumed to be to the Business and Personal Service Sector.) North Dakota tourism receipts are estimated and published annually at the state level.[16] The business volume for tourism was allocated to the regions on the basis of the region's share of state population. The assumption was that areas with higher populations are more likely to possess the services necessary to maintain a tourist trade.

---

[11] New Wealth--North Dakota, Greater North Dakota Association, North Dakota State Chamber of Commerce, North Dakota, 1958-1975.

[12] U.S. Department of Commerce, Bureau of Economic Analysis, Personal Income by Place of Residence, Montana, Wyoming, Washington, D.C., 1976.

[13] U.S. Department of Commerce, Census of Business: Wholesale Trade, North Dakota, U.S. Government Printing Office, Washington, D.C., 1958, 1963, 1967, and 1972.

[14] U.S. Department of Commerce, Census of Business: Wholesale Trade, Montana, U.S. Government Printing Office, Washington, D.C., 1958, 1963, 1967, and 1972.

[15] U.S. Department of Commerce, Census of Business: Wholesale Trade, Wyoming, U.S. Government Printing Office, Washington, D.C., 1958, 1963, 1967, and 1972.

[16] New Wealth--North Dakota, op. cit.

The Travel Promotion Unit of the Montana Department of Highways made tourism estimates for 1967 to 1972 for the state based on such items as gas tax receipts, motel receipts, and number of cars counted by car counters.[17] Straight-line interpolation of the 1967 to 1972 data was used to estimate Montana tourism for the 1973 to 1975 period. Using straight-line interpolation backward from the 1967 to 1972 data would have resulted in a very small dollar amount of tourism expenditures for 1958. Because of the similarities of Montana with North Dakota and Wyoming, such as geographic attractions and respective locations, a percentage increase in tourism similar to that of North Dakota and Wyoming for 1958 to 1966 was used for that time period in Montana. The business volume of tourism allocated to the region in Montana was on the basis of proportion of the state's population in that region, which involved the same assumption as was made for North Dakota.

Data on tourism in Wyoming were very limited. The volume of tourism was estimated for the state in a 1961 study at the University of Wyoming.[18] No other estimates were made until 1971 when the Family Research Institute estimated tourism in the state.[19] Straight-line interpolation was used to make estimates of tourism for years not provided by the two studies. The business volume of tourism allocated to the region in Wyoming was based on the proportion of state population in the region.

---

[17]Montana Travel Industry, Montana Department of Highways, Travel Promotion Unit, 1967-1972, Billings, Montana.

[18]Lund, Richard E., Study on Tourism in Wyoming, University of Wyoming, Laramie, 1971.

[19]Family Research Institute estimated based on 1971 data for article in Better Homes and Gardens Magazine, 1972 edition.

Business and Personal Service (Sector 10)

After the dollar volume generated by tourism has been calculated and allocated to retail trade, the remaining tourist expenditures (25 percent) are treated as final demand to the business and personal service sector.

Households (Sector 12)

The federal government generates basic income to the household sector through payrolls and transfer payments. Federal aid to states and individuals is published annually for North Dakota, Montana, and Wyoming for 1968 to 1967.[20] Defense expenditures, veteran's benefits, Old Age and Survivors' Insurance payments, Workmen's Compensation, and the federal payroll are also included as basic income.[21] The household sector final demand vectors for North Dakota, Montana, and Wyoming were calculated by adding total grants (less highway construction), defense expenditures (except for construction), veteran's benefits, Old Age and Survivors' Insurance, Workmen's Compensation, and federal payrolls.

Total federal expenditures in the states were available on a county basis for 1967 to 1975 for North Dakota,[22] Montana,[23] and Wyoming.[24] The final demand vector for 1967 to 1975 was calculated as follows: farm payments (included as income in Sector 2), construction outlays, and loans were subtracted from the total federal expenditures to obtain final demand vectors at county and state level. The percentage the region was of the

---

[20] U.S. Treasury Department, op. cit.

[21] U.S. Department of Commerce, Bureau of Economic Analysis, Personal Income by Place of Residence, Montana, Wyoming, Washington, D.C., 1976.

[22] U.S. Department of Commerce, Federal Outlays in North Dakota, op. cit.

[23] U.S. Department of Commerce, Federal Outlays in Montana, op. cit.

[24] U.S. Department of Commerce, Federal Outlays in Wyoming, op. cit.

state for 1967 to 1975 was used to allocate the household final demand vector to the regions for the years 1958 to 1966.

Coal Mining (Sector 14)

The total receipts from sales of coal nonlocally comprised the coal mining final demand vector. The production and value per ton were available by mine for North Dakota for the years 1958 to 1975.[25] All coal mined in SR 2 was assumed to be used domestically while in SR 8 all the coal from the Gascoyne mine was assumed to be exported. Coal mined in SR 1 and SR 7 was assumed to be exported in the same proportion as all North Dakota coal.[26]

Production and average value per ton of coal was available by county for Montana for the study years.[27] All coal mined in the region was assumed to be sold outside the region.

Wyoming coal production and average value per ton was available for the study period on a county basis.[28] Coal exported from Wyoming was assumed to be total coal production less coal used for electric generation.[29]

---

[25] North Dakota State Mine Inspector, North Dakota Annual Coal Mine Report, Workmen's Compensation Department, Bismarck, North Dakota, 1958 to 1975.

[26] West, James G., unpublished memorandum to the National Energy Considerations Work Group of Northern Great Plains Resources Program, U.S. Department of the Interior, Washington, D.C., 1973.

[27] Minerals Yearbook, Volumes I and II, Metals, Minerals, and Fuels. U.S. Department of the Interior, Bureau of Mines, U.S. Government Printing Office, Washington, D.C., 1958-1973.

[28] Ibid.

[29] Federal Power Commission, Steam-Electric Plant Construction Cost and Annual Production Expenses, 22nd Annual Supplement - 1969.

Thermal-Electrical Generation (Sector 15)

Sales of electricity outside the local region generated by burning coal constituted the thermal-electrical generation final demand vector. North Dakota thermal-electrical production was available for 1966 to 1975.[30] No coal fired electricity was available for export prior to 1966 in North Dakota. All thermal electricity available for export in North Dakota was produced in SR 7. Values were assigned to exported electricity to arrive at the electric generation final demand vector.[31]

Montana was assumed to have no thermal electricity available for export because of its limited electrical generation facilities and is a net importer of electricity.[32]

Wyoming electrical production was available on a limited basis[33, 34] for the study years. The proportion of electricity exported was assigned a value and considered to be the thermal electric generation final demand vector for Wyoming.[35]

---

[30] Annual Report of the North Dakota Public Service Commission to the Governor and Secretary of State, 75th, 76th, 77th, 78th, 79th, 80th, 81st, 82nd, 83rd, 84th, 85th Annual, Public Service Commission, Bismarck, North Dakota, June, 1966, 1968, 1970, 1972, 1973, 1975.

[31] Owen, Walley, Public Service Commission, Bismarck, North Dakota, interview estimates were made on basis of published reports by major electricity producing companies.

[32] Montana Dakota Utilities, telephone conversation, Bismarck, North Dakota, February, 1976.

[33] Wyoming Energy Consumption, Minerals, Fuels, Electric Generation, and Agricultural Sectors, Bickert, Browne, Coddington, and Associates, Inc., Denver, Colorado, June, 1975.

[34] Steam-Electric Plant Factors-1972, National Coal Association, Washington, D.C., 1972.

[35] Walker, David, Engineering Division, Wyoming Public Service Commission, Cheyenne, Wyoming, telephone interview.

Petroleum/Natural Gas Exploration/Extraction (Sector 16)

Export sales of petroleum and natural gas from the local region constituted the final demand vector for Sector 16. North Dakota crude oil production was available by county for all years in the study period.[36] Values of the crude oil were assigned and export locations were determined to arrive at the final demand vectors for the regions and North Dakota. North Dakota is a net importer of natural gas so no final demand vector was calculated for it.

Montana crude oil production was available for the years 1958 to 1975 by oil field.[37] Prices were assigned to the crude petroleum[38] and origin of exports was used[39] so the final demand vector could be calculated. Natural gas production data also were available for Montana.[40] Prices were assigned to the natural gas[41] and export locations determined. Montana was a net importer of natural gas (from Canada and Wyoming) so no export sales were assumed.

---

[36]Wilborne, Jack, North Dakota Geological Survey Data, University of North Dakota Campus, Grand Forks, North Dakota.

[37]Oil and Gas Conservation Commission of the State of Montana, Statement of Crude Oil Production and Valuation, all Montana Fields, Oil, and Gas Conservation Commission, Helena, Montana, 1958-1975.

[38]United States Average Wholesale Prices of Crude Oil and Petroleum, Products in Eight Refining Markets, Prospective Regional Markets for Coal Conversion Plant Products Projected to 1980 and 1985, prepared for Office of Coal Research, U.S. Department of the Interior, by Energy Division, Foster Associates, Inc., Washington, D.C., September 16, 1974.

[39]Lawson, Jim, Cenex Petroleum Refining, Glendive, Montana, telephone interview; Mr. Peterson, Continental Oil Company, Montana, telephone interview.

[40]Montana Gas Production Data, Oil and Gas Conservation Commission, Helena, Montana, 1958-1974.

[41]United States Average Wholesale Prices of Crude Oil and Petroleum, op. cit.

Wyoming crude oil[42] and natural gas[43] production data were available by year for each oil and gas field. Values were assigned to the products[44] and export amounts and locations were determined[45] to arrive at the petroleum/natural gas by location/extraction final demand vector for Wyoming.

Petroleum Refining (Sector 17)

Export sales of refined petroleum products were calculated for the petroleum refining final demand vector. North Dakota data were not readily available but interviews provided data as to total petroleum products, export destinations, and a refined product breakdown.[46, 47, 48] Values were assigned to the exported refined products to estimate the final demand vector for the petroleum refining sector in North Dakota.[49]

---

[42] Oil Production - Wyoming, by Producers and Fields, Wyoming Oil and Gas Conservation Commission, Casper, Wyoming, 1958-1974.

[43] Gas Production--Wyoming, by Producers and Fields, Wyoming Oil and Gas Conservation Commission, Casper, Wyoming, 1958-1974.

[44] United States Average Wholesale Prices of Crude Oil and Petroleum, op. cit.

[45] Wyoming Energy Consumption, Minerals, Fuels, Electric Generation, and Agricultural Sectors, op. cit.

[46] Feeny, Joe, Amoco Oil Company, Mandan, North Dakota, telephone interview, he gave estimates on total production, exports, and breakdown of refined products for 1958 to 1974.

[47] Public Relations Department, Westland Oil Company, Williston, North Dakota, telephone interview, he gave estimates of production, exports, and breakdown of refined products for 1958 to 1974.

[48] Mr. Thomas, Northland Oil Company, Dickinson, North Dakota, telephone interview, he gave estimates of production, exports, and breakdown of refined products for 1958 to 1974.

[49] United States Average Wholesale Prices of Crude Oil and Petroleum, op. cit.

Montana data were available on petroleum refining by refinery for the years 1958-1975.[50] Prices were assigned to refined products[51] and export amounts and locations determined[52] so the petroleum refining final demand vector could be calculated.

Wyoming data on crude petroleum oil refined were available for the years 1958-1975.[53] Values were assigned to the refined products[54] and estimates of amounts exported were made[55, 56] so the final demand vector could be calculated for the petroleum refining sector.

---

[50]Oil and Gas Conservation Commission of the State of Montana, Barrels of Crude Oil Refined in Montana, Oil and Gas Conservation Commission, Helena, Montana.

[51]United States Average Wholesale Prices of Crude Oil and Petroleum, op. cit.

[52]Lawson, Jim, Cenex Petroleum Refining, op. cit.

[53]Minerals Yearbook, Volume III, U.S. Department of the Interior, Bureau of Mines, U.S. Government Printing Office, Washington, D.C., 1958-1973.

[54]United States Average Wholesale Prices of Crude Oil and Petroleum, op. cit.

[55]Goodier, John, Chief, Mineral Development, Department of Economic Planning and Development, Cheyenne, Wyoming, telephone interview, February, 1976.

[56]Wyoming Energy Consumption, Minerals, Fuels, Electric Generation, and Agricultural Sectors, op. cit.

APPENDIX B

DISAGGREGATION OF PERSONAL INCOME

Personal income is perhaps the best criterion for determining the accuracy with which an input-output model measures the level of economic activity of the state or state region. Personal income reported by the United States Department of Commerce may be compared to that estimated by the input-output model at the state and substate level. However, the personal incomes that are reported for the substate levels of aggregation may be subject to significant errors of estimate. Therefore, an alternative procedure[1] was used to provide additional estimates of personal income at the substate level. This procedure was developed prior to estimated levels being published for substate areas.

The United States Department of Commerce annually publishes data delineating total state personal income as the sum of six components.[2] These disaggregation techniques allocate each of the six components of personal income to its industrial and geographic origin. The allocator used reflects economic activity similar to that which would generate a specific component of personal income. Separate allocation techniques were used for each of the six components: wage and salary payments, proprietor's income, property income, other labor income, transfer payments, and individual contributions for social insurance.

---

[1] Senechal, D. M., Analysis of Validity of North Dakota Input-Output Models, unpublished M.S. thesis, Department of Agricultural Economics, North Dakota State University, Fargo, 1971.

[2] U.S. Department of Commerce, Bureau of Economic Analysis, Personal Income by Place of Residence, intermediate table, Montana, North Dakota, and Wyoming, 1976.

Wage and Salary Payments

The allocator used to calculate each industry's wage and salary payments among the counties was the portion of state total reported wage and salary payments which occurred in a county. The data used to formulate these allocators were based on United States Department of Commerce census data. These census publications were published only at intervals so straight-line interpolation was used to provide allocators for the intervening years. Information for calculating agricultural crops and livestock allocators was available for 1959, 1964, 1969, and 1974.[3] Data for wholesale, retail, and service sectors were available for 1958, 1963, 1967, and 1972.[4, 5, 6] Wage and salary payments are not reported for mining, manufacturing, transportation, construction, communications, and public utilities, finance-insurance-real estate, and government sectors. State totals of wage and salary payments in these sectors were allocated to the county level on the basis of employment (weighted by average retail wage in the county) in each sector in the respective counties in 1960 and 1970.[7]

---

[3]U.S. Department of Commerce, Census of Agriculture, Montana, North Dakota, and Wyoming, 1959, 1964, 1969, and 1974, Washington, D.C.

[4]U.S. Department of Commerce, Census of Business: Wholesale Trade, Montana, North Dakota, and Wyoming, 1958, 1963, 1967, and 1972, Washington, D.C.

[5]U.S. Department of Commerce, Census of Business: Retail Trade, Montana, North Dakota, and Wyoming, 1958, 1963, 1967, and 1972, Washington, D.C.

[6]U.S. Department of Commerce, Census of Business: Selected Services, Montana, North Dakota, and Wyoming, 1958, 1963, 1967, and 1972, Washington, D.C.

[7]U.S. Department of Commerce, Census of Population, Montana, North Dakota, and Wyoming, 1960 and 1970, Bureau of the Census, Washington, D.C.

The annual average wage in retailing was obtained for each county by dividing total county retail wages by the number of employees earning these wages. Retail wages were used because they represent the most general coverage of any wage average and because retail wages provide an indication of differences among counties in wages and income.

Other Labor Income

Other labor income is composed of Workmen's Compensation payments, employee benefits, military reserve pay, and several minor items. The state total for other labor income was allocated to each county in the same proportion as the total of wages and salaries received within the county.

Proprietor's Income

Proprietor's income measures the net receipts of all nonincorporated enterprises, including net income of farmers, professional persons, and others in a self-employed status. A percentage ratio expressing the relationship of a sector's total county sales to total state sales was computed. The data needed for these computations were available for each year for both crop and livestock production.[8] County allocators for proprietor's income

---

[8] Montana Agricultural Statistics, Montana Department of Agriculture cooperating with U.S. Department of Agriculture, Statistical Reporting Service, Helena, Montana, December, 1962, 1964, 1968, 1970, 1974, and 1976.

North Dakota Crop and Livestock Statistics, North Dakota State University, Agricultural Experiment Station, cooperating with U.S. Department of Agriculture, Statistical Reporting Service, Fargo, North Dakota, May, 1960-1976.

Wyoming Agricultural Statistics, Wyoming Crop and Livestock Reporting Service, issued by Wyoming Department of Agriculture, the University of Wyoming, and U.S. Department of Agricultural Statistical Reporting Service, Cheyenne, Wyoming, 1960-1976.

for the census years were calculated for wholesale, retail, and service sectors.[9, 10, 11] The wage and salary allocators for mining were used for mining proprietorship allocators in each county. The same relationship was assumed to exist between wage and salary disbursements in mining and proprietorship income from mining in all counties. Straight-line interpolation again provided allocations for noncensus years.

Total county proprietor's income was computed for the agriculture-crops, agriculture-livestock, wholesale, retail, and service sectors. The sum of county proprietor's income originating in these sectors was the basis for formation of allocators for manufacturing, transportion, construction, communications and public utilities, and finance-insurance-real estate sectors. The county allocator for each of these five sectors was the ratio of county proprietor's income in the five reported sectors to state total proprietor's income originating in their sectors. The assumption was that income occurring to the unreported sectors would be proportional to the level of activity in the reported sectors. The government sector has no proprietor's income.

Property Income

Property income includes income received from dividends, rent, and interest. The Department of Commerce does not categorize property income by industrial source, but only by rent, interest, and dividends. Allocation of property income was accomplished by the use of the same relationships which were assumed for the disaggregation of proprietor's income.

---

[9] U.S. Department of Commerce, Census of Business: Wholesale Trade, op. cit.

[10] U.S. Department of Commerce, Census of Business: Retail Trade, op. cit.

[11] U.S. Department of Commerce, Census of Business: Selected Services, op. cit.

Transfer Payments

Transfer payments consist generally of disbursements from government or business to individuals for which no services are rendered in that specific time period. The federal government is the largest source of transfer payments. The largest individual source of transfer payments is social security benefits. Data on social security benefits were available for the years 1967 through 1975.[12] The county proportion of the state total was used as the allocator. The 1967 allocator was assumed to hold for the years 1958-1966.

Individual Contributions for Social Insurance

Contributions made by individuals under the various social insurance programs are excluded from personal income by treating them as an explicit deduction item. The total state deduction for this category was subtracted from each county's personal income in the same proportion that personal income from the other five components was received.

---

[12] U.S. Department of Commerce, Federal Outlays in Montana, North Dakota, and Wyoming, Office of Economic Opportunity, National Technical Information Service, Washington, D.C., 1967-1975.

LIST OF TABLES

Table No.		Page
1.	ECONOMIC SECTORS OF INPUT-OUTPUT MODEL AND SIC CODE NUMBERS OF EACH	6
2.	INTERDEPENDENCE COEFFICIENTS FOR BASIC ECONOMIC SECTORS, NORTH DAKOTA	7
3.	SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA, 1958-1975 (MILLION DOLLARS)	8
4.	PERSONAL INCOME, NORTH DAKOTA, 1958-1975	10
5.	SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, NORTH DAKOTA REGIONS, 1958-1975 (MILLION DOLLARS)	13
6.	ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, BY REGION, NORTH DAKOTA, 1958-1975	16
7.	SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, MONTANA AND SOUTHEASTERN MONTANA, 1958-1975 (MILLION DOLLARS)	23
8.	ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, MONTANA AND MONTANA REGION, 1958-1975	24
9.	SALES FOR FINAL DEMAND, BY ECONOMIC SECTOR, WYOMING AND NORTHEASTERN WYOMING, 1958-1975 (MILLION DOLLARS)	29
10.	ESTIMATES OF PERSONAL INCOME AND DIFFERENCES IN ESTIMATES, WYOMING AND WYOMING REGION, 1958-1975	30

LIST OF FIGURES

Figure No.		Page
1.	Personal Income in North Dakota, As Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975	11
2.	State Planning Regions in North Dakota	12
3.	Personal Income in Region 1, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975	17
4.	Personal Income in Region 2, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975	18

LIST OF FIGURES (CONTINUED)

Figure No.		Page
5.	Personal Income in Region 7, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975	19
6.	Personal Income in Region 8, North Dakota, as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975	20
7.	Montana and Nine-County Region in Southeastern Montana .	22
8.	Personal Income in Montana, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975	25
9.	Personal Income in Southeast Montana as Reported by U.S. Department of Commerce and as Estimated by Input-Output Procedures and Disaggregation Techniques, 1958-1975 . . .	26
10.	Wyoming and Eight-County Region in Northeastern Wyoming .	27
11.	Personal Income in Wyoming, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975	31
12.	Personal Income in Northeast Wyoming, as Reported by the U.S. Department of Commerce and Estimated by Input-Output Procedures, 1958-1975	32